05
)
:0

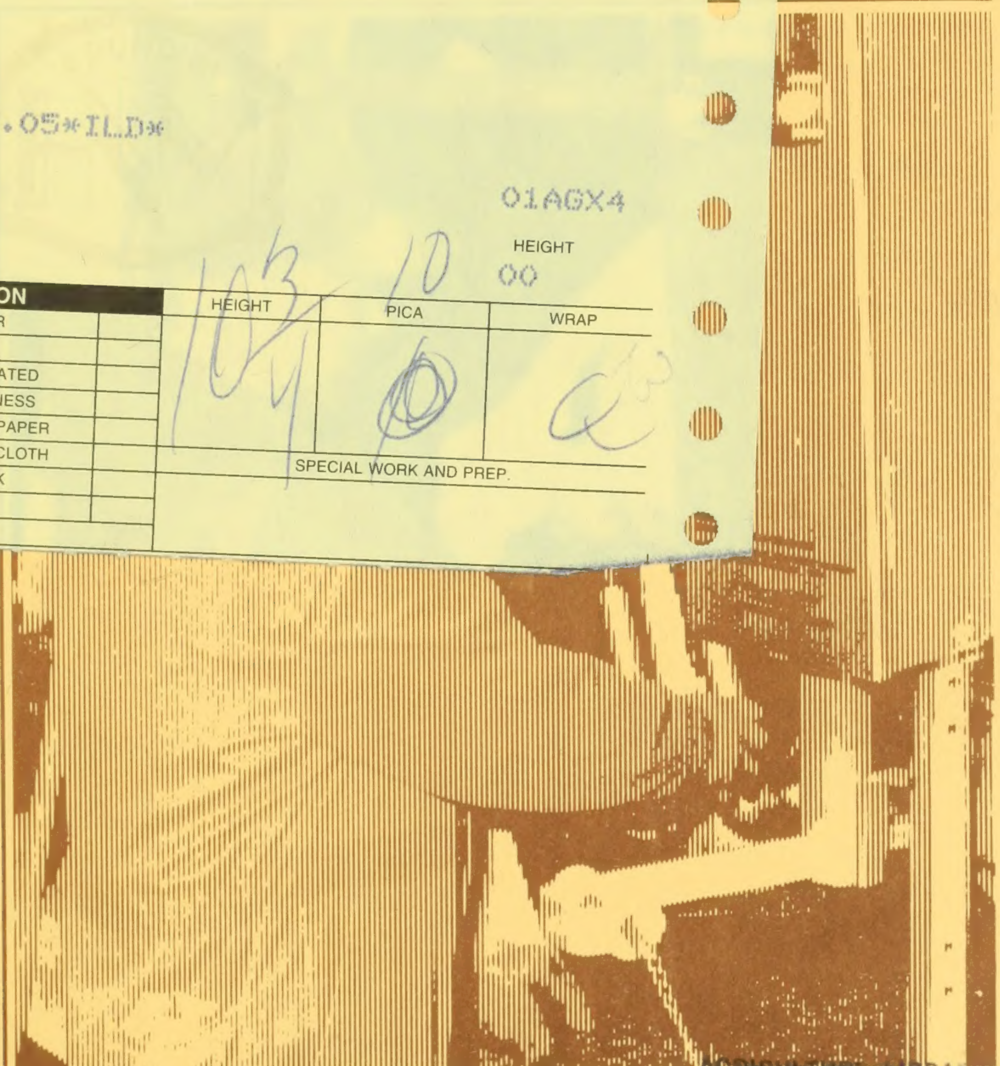
2/5

15A-31

1980 Illinois Dairy Report

Department of Dairy Science
Cooperative Extension Service
Agricultural Experiment Station
College of Agriculture
University of Illinois
Urbana-Champaign

Harvesting Your Milk Potential



1980 Illinois Dairy Report

Department of Dairy Science
Cooperative Extension Service
Agricultural Experiment Station
College of Agriculture
University of Illinois
at Urbana-Champaign

Harvesting Your Milk Potential

1980 Illinois Dairy Days

January 11	Peoria, Heritage House		January 21	Kankakee, Redwood Inn
16	Effingham Extension Center		22	Woodstock, Timbers Restaurant
17	Breese, American Legion Hall		23	Freeport, Holiday Inn
18	Quincy, Ramada Inn		24	Sterling, Emerald Hill Country Club

Authors

Department of Dairy Science, University of Illinois at Urbana-Champaign, except as noted

SHELIA M. ANDREW, research assistant

MARVIN P. BRYANT, professor, ruminant microbiology

JIMMY H. CLARK, associate professor, dairy cattle nutrition

BRUCE O. DOKKENBAKKEN, manager for Illinois and Iowa, DHIA, Dubuque, Iowa

CARL L. DAVIS, professor, ruminant nutrition

ROBERTA P. DURSCHLAG, research assistant

CHARLES N. GRAVES, associate professor, reproductive physiology

GARY W. HARPESTAD, associate professor and Extension dairyman

ROBERT B. HESPELL, assistant professor, microbiology

MICHAEL F. HUTJENS, professor and Extension dairyman

BARRY W. JESSE, former research assistant

RALPH V. JOHNSON, associate professor and Extension dairyman

BRUCE L. LARSON, professor, biochemistry and lactation and Acting Head of the Department

ANDREW J. LEE, former assistant professor, genetics

JAMES L. ROBINSON, associate professor, biochemistry

ROGER D. SHANKS, assistant professor, genetics

SIDNEY L. SPAHR, associate professor, dairy cattle management

CHANDRA M. SHRESTHA, former graduate student

LARRY J. THOMPSON, research assistant

MOHEMMAD A. WAHEED, graduate research assistant

Contents

1980 THEME: HARVESTING YOUR MILK POTENTIAL

UNIVERSITY OF ILLINOIS RESEARCH REPORTS

The Department of Dairy Science

BRUCE L. LARSON

THE DEPARTMENT OF DAIRY SCIENCE is pleased to provide you with the 1980 Dairy Report. We expect it to be the first in an annual series of such reports. The 1980 report provides summary information about timely topics on the Dairy Day Program and about various research projects in the department.

The Dairy Report is designed to augment other statewide educational programs and publications provided by the department, publications such as the *Illinois Dairy Digest* and the *Illinois Dairy Herd Improver*. As dairy farmers in Illinois, we want you to know that the Department of Dairy Science exists to help the Illinois dairy industry through its programs of teaching, research, and service in its extension activities.

The department's teaching program is designed to provide a full range of academic opportunities at the undergraduate and graduate levels. A four-year college program is available for undergraduate students who major in dairy science. A graduate program is also offered so students specializing in various areas that are important to dairy science can work on advanced degrees. When college time arrives for your sons and daughters, we hope you will give serious consideration to sending them to the University of Illinois.

Exciting things are happening on the Urbana-Champaign campus. One of them is the Food for Century III Program through which the College of Agriculture is making major improvements in its facilities. At the Dairy Research Farm, several new construction projects are underway. Extensive remodeling is also being done. These building and remodeling projects include a new heifer-raising unit, new feeding facilities, and a polygon milking parlor--the first one is Illinois. The polygon parlor will have a highly automated system including a mini-computer that will be used to sense physiological conditions and record data. We invite you to see the units now nearing completion.

The faculty members in the Department of Dairy Science are listed below. Many of them have prepared articles for the 1980 Dairy Report. We also want you to know the Illinois dairy farmers who serve as your representatives on the Industry Advisory Committee to the Department of Dairy Science. The current members of the committee are: William Lenschow, Sycamore; Kevin Lyons, Granville; William McFadden, Apple River; Gordon Ropp, Normal; and Dale Schaufelberger, Greenville.

The faculty of the department and the members of the committee welcome your comments and questions concerning the Department of Dairy Science and its various functions and responsibilities. We thank you for your interest and hope you will find the 1980 Illinois Dairy Report of value.

Full-time faculty members	Specialization
Craig R. Baumrucher, assistant professor	Lactation
Marvin P. Bryant, professor	Ruminant microbiology
Jimmy H. Clark, associate professor	Dairy cattle nutrition
Carl L. Davis, professor	Dairy cattle nutrition
Charles N. Graves, associate professor	Reproductive physiology
Michael Grossman, associate professor	Dairy cattle genetics
Gerhard W. Harpestad, associate professor	Extension dairyman
Kenneth E. Harshbarger, professor	Dairy cattle nutrition (on assignment, MUCIA, Jarkarta Office, Indonesia)
Robert B. Hespell, assistant professor	Ruminant microbiology
Michael F. Hutjens, professor	Extension dairyman
Edwin H. Jaster, assistant professor	Dairy cattle management
Ralph V. Johnson, associate professor	Extension dairyman
Bruce L. Larson, professor and Acting Head of the Department	Biochemistry and lactation

J. Robert Lodge, professor	Reproductive physiology
James L. Robinson, associate professor	Biochemistry
Roger D. Shanks, assistant professor	Dairy cattle genetics
Sidney L. Spahr, associate professor	Dairy cattle management

The Dollars and Sense of Selecting for High Milk Production

ROGER D. SHANKS

BY SELECTION, DAIRYMEN CAN IMPROVE the dairy cattle population. The prerequisites for selection are accurate records of milk production and proper sire identification. Such data should be maintained for 11 million dairy cows in the United States. At present, though, milk production is recorded for less than 40 percent of the cows; also, the milk records for 1 out of 3 cows do not identify the sire or contain sire identification that is unsuitable for use in genetic evaluations. As the number of dairy cows declines, accurate information about the performance and background of individual cows becomes critical for evaluation.

Milk production is the most important trait, one that should be measured for all dairy cows. Measurements of other traits become important as the emphasis shifts from single-trait selection for higher milk yields to a selection that will maximize profits for the dairyman (or minimize losses). As noted, the major trait is milk production. Other traits are used to "fine-tune" the economic evaluation of genetic potential.

Four techniques for maximizing profits through selection and management are discussed.

1. Use bulls for artificial insemination rather than natural service.

2. Chose herd replacements with high pedigree estimates of breeding value.

3. Select bulls with high predicted differences for milk.

4. Reduce health costs for the dairy herd through alert management.

Results from DHI data and tests with research herds support the use of these techniques, as will be shown here.

USE AI BULLS

The average predicted differences for AI and non-AI bulls are shown in Table 1. Research geneticists for the USDA have reported the average predicted differences for sires of the cows on DHI calving at their first lactation in 1978. The predicted differences for AI for sires averaged $52, 525 pounds of milk, and 16 pounds of fat more than for non-AI sires. Using AI sires is fundamental to a sound breeding program.

The AI organizations have a large number of sire analysts working to improve the next generations of sires. The AI organizations select bulls from special matings based on pedigree evaluations and retain them according to progeny testing.

HERD REPLACEMENTS WITH HIGH PEDIGREE ESTIMATES

Pedigree evaluations are not restricted to AI organizations. Herd replacements can be selected according to pedigree evaluations.

Table 1. Average Predicted Differences for AI and Non-AI Bulls

Type of daughter	Average predicted differences: Dollars	Milk (lb.)	Fat (lb.)
AI sire	61	681	16
Non-AI sire	9	156	0

Source: Powell, R.L., and F.N. Dickinson. "Average of Bull's PD's by State," *Hoard's Dairyman*, September 10, 1979, p. 1,119.

In 1968, Iowa State University initiated a project on breeding dairy cattle at Ankeny, where the research herd is located. The project was intended to evaluate the success of single-trait selection for milk production and to determine the correlated responses in terms of health problems. The researchers wished to establish the practicality of selection for high milk production. Health problems were monitored to see if more of those problems would be associated with such selection.

To start the project, 43 open Registered Holstein heifers were pruchased from Iowa dairymen. One heifer from each pair was selected for high milk production, the other for low production. The pedigree estimate of breeding value (PEBV) from the replacement female evaluation (DHIA 200) was used as the measure of milk production for the heifers. The pedigree estimate of breeding value is the sum of the predicted difference (PD) of the sire and the estimated average transmitting ability (EATA) of the dam.

The difference between the high and low pedigree estimates averaged +1,676 pounds of milk. After calving, the heifers selected for high breeding values out-produced those chosen for low breeding values by an average of 1,330 pounds of milk (305-day, mature-equivalent basis).

The heifers with high pedigree values earned an average of $59 more in income over feed costs per lactation than the ones with low values. The health costs averaged $13 more per lactation per animal for the heifers with high PEBV's than for those with low values. Because the high heifers produced more milk than the others, the largest component of the increased health cost was the value of unsaleable milk.

The net income (milk income minus feed and health costs) averaged $46 more for the heifers selected for high breeding values than for those with low values. Selecting for high PEBV's did increase the health costs, but the net income from those heifers was also higher. So selecting herd replacements according to the pedigree estimate was successful in yielding greater milk production and higher net income.

SELECT BULLS WITH HIGH PREDICTED DIFFERENCES FOR MILK

The purchased heifers were bred to bulls with high or average predicted differences for milk production. For the 7 high bulls, the predicted differences for milk averaged +1,380 pounds. For the 7 bulls with average PD's for milk, the average was +35 pounds, for a difference of +1,345 pounds of milk. After calving, the daughters of the sires with high PD's produced an average of 2,670 more pounds of milk (305-day, mature-equivalent basis) than those of the sires with average predicted differences. Thus, selecting for high predicted differences was successful in raising milk production.

The daughters of sires with high PD's earned an average of $88 more in income over feed costs than those of sires with averaged predicted differences. All daughters of high sires were bred to high sires. The additional health cost per animal averaged $10 per lactation, primarily because the semen from bulls with high PD's cost more than other semen.

The net income per lactation was $78 more for daughters of sires with high PD's, compared to the daughters of sires with average predicted differences. By selecting sires with high PD's, the cost of semen was higher but so was the milk production from the daughters. Hence, the net income per lactation was greater for the daughters of bulls with high PD's than for the daughters of bulls with average predicted differences.

What is a high predicted difference for milk production? For Holstein bulls, a PD of +1,000 is not high. Based on the Sire Summary for the summer of 1979, the average PD was +928 for 686 active AI Holstein bulls. By next summer, the average PD for Holstein bulls in AI service will be above +1,000. So a PD of +1,000 is only 72 above the average for last summer (928) and will be below the average by next summer.

When the measure is predicted difference for milk, the genetic trend for all dairy breeds is positive. The USDA research geneticists use a constant base in calculating predicted differences. All bulls are compared to the average bull in 1974 (PD 74). The relation between the genetic trend and the genetic base for Holsteins is shown in Figure 1. With the constant genetic base, breed improvement depends on increasing the selection goals by 100 to 200 pounds of milk each year.

The average predicted differences by breeds for the summer of 1979 are shown in Table 2. The Jerseys had the highest PD's for milk, fat, and dollars but their percentage of butterfat declined the most. Only the milking Shorthorns increased their average test for butterfat.

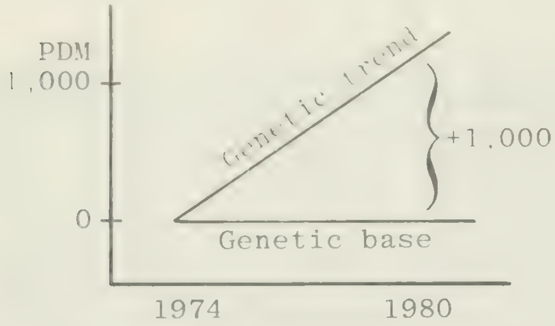


Figure 1. Holsteins, genetic trend against a constant base.

Table 2. Average Predicted Differences, Bulls in Active AI Service, Summer, 1979

	No.	PDM (lb.)	Percent butterfat	PDF (lb.)	PD$
Ayrshire	20	+570	-.02	+20	+ 59
Guernsey	42	+749	-.07	+28	+ 80
Holstein	686	+928	-.06	+24	+ 86
Jersey	86	+982	-.17	+33	+100
Brown Swiss	46	+782	-.05	+25	+ 78
Milking Shorthorn	12	+794	+.02	+31	+ 87
All breeds	892	+908	-.05	+25	+ 86

REDUCE HEALTH COSTS

The way to lower health costs is through alert management, not selection. Probably less than 10 percent of the variation in health costs among cows can be changed by selection. Some females may have high health costs and may need to be culled, but culling will have little effect on the future health costs in the herd because cows do not tend to have high health costs in successive lactations. However, milk production in the first lactation is a good indicator of future production. The heritability of milk production as a selection factor is about 0.25 while that of health costs is near 0.06. The large heritability value indicates a greater opportunity to select for higher milk production. The small value indicates that selecting for reduced health costs is not practical.

Data from 551 cows with 1,305 lactations from 2 research herds at Beltsville, Maryland and Waseca, Minnesota were analyzed to determine the occurrence of health costs.

1. Mamary disorders, such as mastitis, udder injury, edema, and dry treatment.

2. Reproductive disorders, including calving difficulty, retained placenta, and metritis.

3. Inseminations (number of breedings).

4. Locomotive disorders, such as foot rot, leg injuries, and hoof trimming.

5. Digestive disorders, including hardware, displaced abomasum, and being off-feed.

6. Respiratory disorders, such as pneumonia, shipping fever, and bronchitis.

7. Other health costs, including external injuries and preventative vaccinations.

The out-of-pocket health costs were summarized by category. The first two categories were the ones with the greatest costs and frequency. Of the total health costs, mammary costs made up 34 percent ($1.74 per cow per 30-day interval in the herd) and reproductive costs 21 percent ($1.06 per cow per 30-day interval). The total health cost per cow (including inseminations) averaged $5.09 per 30-day interval. These data are summarized in Table 3.

Health costs were not distributed uniformly throughout the lactation. The highest costs, 20 percent of the total, occurred during the first 30 days after calving. Mammary and reproductive costs made up 71 percent of the total during the first 30 days after calving. During early lactation, cows need to be monitored closely to anticipate and prevent excessive health costs.

Data from 863 cows with 1,999 lactations from 3 research herds in Ankeny, Iowa, Beltsville, Maryland, and Waseca, Minnesota were analyzed to determine the relation of health costs to the length of the lactation, milk production, and age at calving. Total health costs (not including inseminations in this case) averaged $37 per cow per lactation. The major ones were mammary and reproductive disorders at $18 and $12 on the average per lactation, respectively.

Table 3. Health Costs by Category per 30-Day Interval

Category	Average per cow	Pct. of total
Mammary	$1.74	34
Reproductive	1.06	21
Inseminations	.95	19
Locomotive	.32	6
Digestive	.14	3
Respiratory	.10	2
Other	.76	15
Total	5.09	100

Calving intervals of 370 to 390 days were associated with the lowest health costs. Calving intervals of more than 420 days had the highest costs for health care. The maintenance figure for health costs average about 10 cents per cow per day.

High health costs were associated with milk production of under 12,100 pounds and over 17,600 pounds. An intermediate range of milk production was associated with the lowest costs for health care. The performance of low-producing cows may have been hindered by health disorders. The high-producing cows may have experienced the stress of high production, thus increasing the associated health costs.

The analysis also showed that health costs went up with each lactation, from $6 per cow below the average to $9 above the average from the first to the fourth lactations. At calving, the total health cost increased by 78 cents per cow for each additional month of age.

RECOMMENDATIONS

1. Keep accurate records on milk production and sire identification for each cow in the herd.

2. Select dairy cattle for maximum profit. Choose herd replacements with high pedigree estimates of breeding value. Pick AI bulls with high predicted differences for milk.

3. Increase the selection goals annually, by 100 to 200 pounds of milk.

4. Reduce health costs and thus raise profits through alert management.

Harvesting Your Milk Crop

RALPH V. JOHNSON

YOU DRAW YOUR PAYCHECK for your work when you harvest your milk crop twice a day. Milking time deserves your full attention if you intend to get maximum returns from your efforts in breeding, feeding, and management.

To get such returns, a dairyman must use good milking techniques and a machine that will milk the cows efficiently. The milking machine is the most important piece of equipment on the dairy farm. It is used more often and more hours per year than any other piece of equipment, including the farm tractor. Still, many people tend to neglect the milking machine, and do not know how the equipment functions in removing milk from the udder.

All modern milking machines operate on the same basic principle. Milk is removed from the udder by differential pressure. After milk letdown occurs, the pressure within the udder increases and is slightly higher than the atmospheric pressure. A partial vacuum exists in the inflation in the teat cup. When it is placed on the cow's teat, the milk will flow from the

udder (where there is higher pressure) into the partial vacuum (where there is lower pressure). This must be accomplished without irritation to sensitive tissue of the teats and udder.

ESSENTIAL COMPONENTS OF A MILKING SYSTEM

An explanation fo the function and operation of each major component of a mechanical milking system is given here, along with guides for proper operation, to help dairymen do a better job of "harvesting their milk crop."

THE VACUUM SUPPLY SYSTEM

The funtion of the air pump (commonly called a vacuum pump) is to remove most of the air from a closed system, thereby creating a partial vacuum. The amount of air removed and the extent of the vacuum created are regulated by a control valve. This valve allows air to enter the system when the desired vacuum level is reached in the system. Control valves must be cleaned periodically and watched constantly to see that they do not stick.

Air pumps must be able to remove more air from the system than is needed by the milker units. Unde current recommendations, the air pump should remove 8 to 10 cubic feet of air per minute (CFM) for each milker unit used on a pipeline system.

Pumps are rated according to the amount of air they remove from a system. The American Standard Method (ASME) is based on the rate at which air is removed under a normal atmospheric pressure of about 30 inches of mercury per square inch. This standard is used to rate the pumps made by most companies. The New Zealand Method (NZ) is based on the volume of air removed at a reduced pressure of 15 inches of mercury. Boumatic and Surge pumps are rated by the NZ method. A pump that delivers 20 CFM according to the ASME standard will deliver 40 CFM under the NZ standard. When checking pumps or making comparisons, you need to know which rating sytem was used.

THE PULSATION SYSTEM

The function of pulsators is to increase and decrease the partial vacuum between the teat-cup shell and the liners. See Figure 1. The result of a good pulsator action is teat massage and an intermittent relief of the effect of vacuum on the teats. This stimulates the flow of blood in the teats and prevents congestion and possible damage to the ends of the teats.

The number of times per minute the pulsator alternates between the milking and rest phases is called the pulsation rate. The rate refers to the amount of time the teat-cup liner is in each phase, milking and rest. Always operate your machine according to the manufacturer's recommendations.

Pulsators must be checked on a regular basis to see if they are operating properly. Plugged air holes, leaks, or worn parts will reduce the efficiency of a pulsator.

THE MILKING UNIT

The milking unit includes the teat-cup assembly, claw or suspension cup, as well as the connecting air and milk tubes. The liners used must correspond to the size of teat-cup shell. Liners that are too large or small for the shell will not collapse properly. The result can be an inefficient operation of the milking machine.

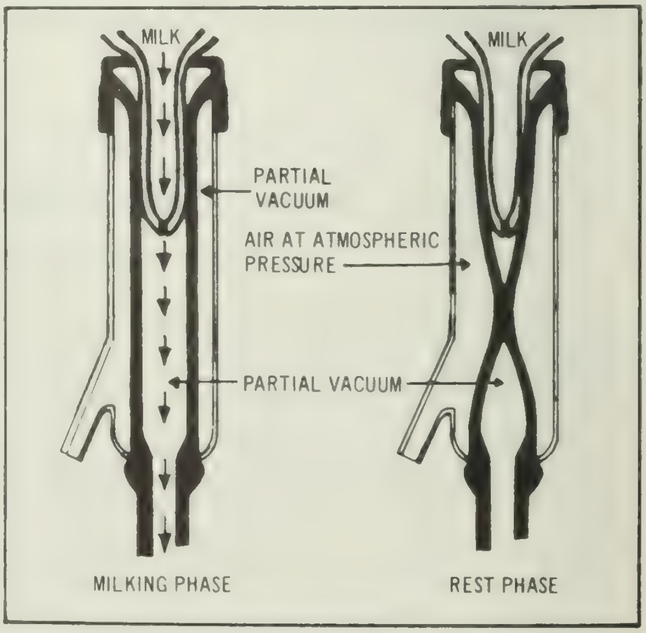


Figure 1. Principle of milker operation. (From "The Modern Way To Efficient Milking," published by the Milking Machine Manufacturers Council, 1977.)

Most companies recommend the use of narrow-bore liners that are 3/4-inch or less in internal diameter. Narrow-bore liners are less prone to teat-cup crawl and damage to udder tissue than other liners, but the unit may drop off more frequently.

The expected life of most inflations is 1,000 milkings. Using alternate sets of inflations every 7 to 10 days will extend the useful life of most inflations. Thoroughly clean the inflations before they are placed in storage boxes for the rest period.

THE MILK FLOW SYSTEM

The simplest system is the bucket milker. In pipeline installations, the milk line conveys the milk to the milk receiver.

The height of the pipeline should never exceed 7 feet above the cow's udder, preferably much less. Above 7 feet, each additional foot of pipeline heighth results in a drop of ½ inch of vacuum at the teat end when the milk flow approaches 10 pounds per minute. When the milk line is too high, it becomes nearly impossible to maintain a steady vacuum level at the teat end.

In a milking parlor, weigh jars should be placed so the milk inlet ports are about the same heighth as the cows' udders. This helps stabilize the vacuum on the teat end because the lifting of milk above the udder is reduced.

Because the milking machine is used daily, efficiency can go down gradually so that the operator may not be aware of the change. Therefore, a maintenance check list should be followed. Use the list provided by the manufacturer or follow the schedule and check list shown.

Check List For Maintenance Schedule:

Item	Frequency Each Milking	Frequency Each 50 hrs
Check all rubber parts (breaks, tears and water in shell)	X	
Check pulsators and claw breathers	X	
Check trap, belt tension, and oil in pump	X	
Check vacuum levels	X	
Check stallcocks and valve gaskets		X
Clean air tubes and vacuum lines		X
Clean vacuum controller		X
Clean pulsators		X
Check milk pump for leaks		X
Check receiver jar probes		X

Dealer checks: A check of the system should be made by the dealer at six month intervals as follows:

Item	Equipment Needed
Air delivery by pump	Air flow meter
Air movement beyond leaks, pulsation, and friction losses (reserve air flow)	Air flow meter
Pulsation rate	Stop watch
Pulsation ratio	Vacuum recorder
Rest-massage ratio	Vacuum recorder and gauge
Vacuum stability at teat end under full load	Vacuum recorder
Line voltage	Voltmeter

Source: Milking Equipment and Installations, Leaflet DG 504, Cooperative Extension Service, The Ohio State University.

MILKING PROCEDURES AND COW MANAGEMENT

The little things you do, or don't do, can make a lot of difference in handling your dairy herd. For example, following a good routine in harvesting the milk crop can help you save time, produce high-quality milk, and help hold down mastitis problems to a minimum. The recommended practices for rapid, complete milking are summarized below.

1. Sanitize all milking equipment before you start milking.

2. Wash and massage the teats and udder with warm water containing a sanitizer 30 seconds to 1 minute before attaching the milker. Use single-service paper towels to wash, sanitize, and dry the teats and udder before milking.

3. Use a strip cup to check for abnormal milk.

4. Attach the milking machine when letdown occurs (approximately a minute after starting to stimulate the udder). Increased udder pressure from milk letdown remains for as long as

10 minutes in most cows, starting to drop 4 to 5 minutes after stimulation begins. Any delay in attaching the machine means that the cow cannot give you her full cooperation. This can result in a slow or incomplete milking, frequently both.

5. Adjust the teat cups during milking to be sure the milk is removed from the quarters properly.

6. Machine strip by applying a downward pressure on the teat claw and massaging each quarter with a gentle, downward motion. This can be completed in 15 seconds or less on most cows if they were properly stimulated for milk letdown and if the machine was attached when letdown occured. Shut off the vacuum and remove the teat cups as soon as the flow of milk stops.

7. Disinfect the teats by dipping them in a safe and effective product. Research has shown that the rate of new mastitis infections can be reduced by 50 percent by using the proper teat-dipping procedures.

8. Dip the teat cups properly in a disinfectant solution. This can reduce the number of mastitis-causing organisms transferred from cow to cow.

9. Milk the cows without mastitis infections first. Milk the mastitic cows last. This helps to reduce contamination of uninfected cows.

Proper, well-managed milking requires concentration. A good milker is concerned about his cows and develops a routine so that each cow can be treated as an individual. Attempting to use too many units will reduce the operator's ability to perform the necessary steps on time.

THE ROLE OF SOMATIC CELL COUNTS IN MASTITIS CONTROL

Somatic cells, composed of leucocytes and milk-secretion cells, are normal constituents of milk. The leucocyte count rises in response to bacterial infection, tissue injury, or stress. An increase in the concentration of somatic cells in milk is largely due to the leucocytes, which relates to the level of mastitis infection in the herd.

Individual cases of mastitis may be defined as clinical or subclinical, depending on the severity of the infection. Clinical cases are easily detected by the presence of abnormal milk or by an abnormal udder condition. In subclinical mastitis, the udder and the milk look normal.

For mastitis control, the task is to find these hidden problems in a herd. Controlling subclinical nastitis is important because: (1) over a third of the cows with subclinical infection at calving time will become clinically infected during that lactation; (2) milk-secreting cells are destroyed, thus reducing milk production; and (3) these hidden infections are frequently the source of bacteria that contaminate uninfected cows.

A Somatic Cell Count (SCC) Program is available to all Illinois dairymen. The program is intended to create an awareness about the extent of mastitis infections in a herd and to measure the level of infection. Reports from the SCC Program will identify problem cows or groups of cows in the herd. Although cows with high counts will be identified, the reports will not indicate which quarter or quarters are infected. To determine that, use the California Mastitis Test (CMT). Then, consult your veterinarian and set up a treatment program. Many veteranarians prefer to take samples from quarters with high cell counts in order to isolate the organism(s) involved in the infection.

Use the following guides to interpret somatic cell counts from individual cows. (1) Cows with counts of less than 500,000 are generally considered as uninfected, but there are exceptions. (2) To locate these exceptions watch cows with cell counts of over 400,000 for 2 or 3 months and use the CMT if the cell counts start to rise. (3) Consider using the CMT on all cows with counts of over 500,000. (4) Consult your veterinarian about any cow with a count of over 1,000,000. (5) Cull all cows with persistent counts of over 800,000 for 2 or

more lactations and when 2 or more quarters have not responded to treatment. (6) Do not get too excited about a single test result. Results from 2 or 3 months give you a better picture.

Mastitis is a herd problem. If the majority of the cows in the herd have high cell counts, check the milking equipment and the milking practices.

Your Challenge: Peak Milk in 60 Days

MICHAEL F. HUTJENS

DAIRY COWS ARE FORCED to make major metabolic and nutritional adjustments throughout the lactation and gestation cycle. The cow shifts from low nutrient needs for maintenance and fetal growth to high requirements for large quantities of milk 2 to 4 weeks after calving. Losses occur when dairy producers cannot control metabolic and nutritional disorders traced to the dry period and early lactation. A sound program for the dry period and a controlled transition to the milk ration can result in an extra 500 to 3,000 pounds of milk per cow per lactation.

DRY COW MANAGEMENT

The dry period was considered as a time for cows to replace lost body condition and to rest. Recently, greater attention has been given to the management programs for the dry period because of the "fat cow syndrome," higher levels of milk production, and health problems in the herd. Guides for a successful dry-cow program are listed below.

1. *Condition cows before drying-off occurs.* Milking cows in the late-lactation period are more energy efficient (61 percent) compared to dry cows (48 percent) in converting feed to body weight gains. All dry cows can be fed a ration to cover maintenance and pregnancy needs without risking problems with the fat-cow syndrome.

2. *Separate the dry cows from the milking herd.* As Table 1 shows, the dry cows have nutrition requirements that are different from those of cows in lactation.

3. *Build a specific ration to meet the nutritional needs of dry cows.* The form and the type of forage should be considered. Long forage is best, if available. Limit the intake of corn silage in order to avoid excess energy consumption, or dilute it with stovers, straws, or lower-quality forage. Use a coarse-textured, low-energy grain mixture to deliver the desired levels of minerals and vitamins in the ration (Table 2). The amount of grain is dictated by the quality and amount of forage, the body condition of the cows, and their growth needs. Generally, 2 to 4 pounds of grain a day will be adequate. In many herds, no grain is needed (excess energy is already being consumed).

Table 1. Ration Nutrient Requirements of Dry Cows and Cows Producing 50 Pounds of Milk (100 Percent Dry-Matter Basis)

Nutrient	Dry cows	Lactating cows
Protein (%)	11	15
TDN (%)	60	71
Net Energy (M-cal./lb.)	.61	.73
Calcium (%)	.37	.54
Phosphorus (%)	.26	.38
Vitamin A (IU/lb.)	1,450	1,450
Vitamin D (IU/lb.)	140	140

4. *Avoid short and long dry periods.* A dry period of less than 40 days does not allow enough time for udder involution. A long dry period of more than 70 days can result in nutritional imbalances. Comparing cows with dry periods of 60 and 20 days, North Carolina researchers reported a difference of 1,734 pounds of milk in the next lactation.

Table 2. Example of a Grain Ration for Dry Cows

940 pounds of cereal gran (oats, barley, corn and cob meal, bran, or beet pulp)
40 pounds of calcium-phosphorus mineral -legume forage (monosodium phosphate or its commercial equivalent) -grass and corn silage (dicalcium phosphate or its commercial equivalent)
10 pounds of a vitamin A & D premix -1,500,000 units of vitamin A per pound of premix -500,000 units of vitamin D per pound of premix
10 pounds of trace-mineral premix

5. *Control mastitis.* Continue to dip the teats for several days after milking stops. Dry-treat selected quarters if mastitis is not a major herd problem; otherwise, treat all quarters. Use an effective preparation. Follow the directions on the label carefully.

6. *Avoid the fat-cow syndrome.* Feed a balanced ration to prevent excessive weight gains during the dry period. Limit weight increases to 200 pounds if the cows are in good condition.

7. *Prevent milk fever.* Avoid high-calcium rations (over 100 grams per day) during the dry period. Provide 35 to 40 grams of phosphorus per cow per day. Cows prone to milk fever can be fed a calcium-deficient ration 4 to 10 days before calving.

8. *Minimize udder edema.* Avoid excessive intakes of grain and salt. The severity of edema may be reduced by starting to milk before calving and thus increasing the blood flow through the mammary gland. Use diuretics under the direction of a veterinarian.

9. *Control grain feeding just before calving ("lead feeding") to a maximum of 1 percent of body weight.* Heavy grain feeding (15 to 30 pounds) during the 2 weeks before calving can lead to health problems such as a twisted stomach and off-feed conditions and will not increase the intake of dry matter after calving. Some grain (4 to 6 pounds per day) should be introduced in the ration 2 weeks before calving in order to establish rumen microflora for the higher grain diets that will be fed after calving.

10. *Consider a deworming program.* Treat cows at calving time with an approved dewormer to minimize the effect of worms in early lactation (greater peak milk and persistency). Wisconsin research reported 423 more pounds of milk per cow per lactation for treated cows compared to untreated animals.

11. *Avoid retained "after birth" or placenta.* Feed or inject vitamin A or selenium to reduce incidences of cows' not cleaning that did not have calving complications (twins, early birth, or other difficulties). Keep the cows from becoming fat.

12. *Prevent twisted stomach (displaced abomasum).* Feed a minimum of 5 pounds of long forage or avoid finely ground or chopped feeds. Blended rations are best when high levels of grain are fed. Control diseases such as mastitis and metritis and metabolic disorders.

13. *Avoid ketosis (acetonemia).* Gradually increase grain intake (1 to 2 pounds per day) after calving to avoid indigestion and to keep the cows from going off-feed. Limit grain feeding ("lead feeding") to 1 percent of the body weight. Use propylene glycol as a source of blood sugar before the cows are off-feed. Avoid having fat cows since such cows have a depressed appetite.

FEEDING STRATEGIES AT CALVING

If the dry cow program has been sound, difficulties at calving time should be minimal. "Fat" cows are more susceptible to metabolic disorders, going off-feed, contracting infectious diseases, and having retained placenta. Maintain rumen digestion and distention with long forage, since reduced feed intake occurs at calving accompanied by less movement in the rumen. Any major ration changes at calving time should be done gradually (shifting from hay to corn silage and grain, for example). Sodium bicarbonate can stabilize rumen fermentation and increase the intake of dry matter while making major ration changes. Consider placing dry cows in a group receiving blended rations containing feeds used in the high production group 2 weeks before calving.

EARLY LACTATION MANAGEMENT

During the early stages of lactation, the demand for nutrients by the high-producting cows is greater than the feeding program can deliver. The highest level of fat-corrected milk occurs as early as 2 to 4 weeks after calving (Figure 1). Peak milk production happens at 8 weeks, while the peak intake of dry matter comes later (14 to 16 weeks after calving). Body reserves can help meet nutrient needs. One pound of lost body weight can yield 2.2 megacalories of net energy for lactation and ¼ pound of protein. Figure 2 shows curves for changes in milk production, fat test, dry-matter intake, and body weight. If the intake of nutrients is deficient, the result may be reduced milk production (a lower peak milk or shorter persistency, as in Figure 1), ketosis, metabolic disorders, or impaired reproductive performance. Here are feeding tips for high-producing cows.

1. *Challenge cows nutritionally to reach their maximum milk production.* For each pound of increase in peak milk, there will be a 200-pound increase for the total lactation.

2. *See that protein needs are met by providing natural proteins low in rumen degradation.* Top-dress protein or increase the level of protein in the total ration to meet milk production needs and to utilize the fat reserves in the cow's body. Be aware of protein sources and the quality of forages and grains (solubility, amino acid levels, effect of processing, and fermentation breakdown).

3. *Ensure a maximum intake of dry matter.* To do this, use top-quality forage, feed ration components frequently (blended rations), select palatable grains, and avoid wet rations (ones with a total moisture content of over 60 percent).

4. *Maintain optional rumen digestion and pH.* This can be done by providing an adequate amount of fiber (6.5 to 7 pounds of crude fiber) and minimal forage levels (1.5 percent dry matter of the body weight), and by limiting the use of finely chopped or pelleted forages to ensure rumination.

5. *Increase grain to a maximum of 55 percent of the total ration on a dry-matter basis (50 percent with corn silage forage) and use high-quality forages.* Such rations will provide the cows with a maximum of digestible nutrients. Excessive starch levels and high-energy grains (shelled corn or wheat) can cause lower fat tests, rumen acidosis, and off-feed conditions. Oats, ear corn, or beet pulp can improve the grain mixture if fat tests are a problem. Although added fat increases the energy in the ration, consider the economics. A maximum of 7 percent total fat in the ration is the upper limit.

6. *Minimize the amount of nonprotein nitrogen consumed during early lactation.* Illinois research clearly indicates a lower peal milk performance and lower yields from urea-supplemented rations compared to soybean meal rations on a protein-equivalent basis.

7. *Adjust the nitrogen-to-energy ratio in the ration to maximize protein and energy utilization and milk production.* Shortages of nitrogen slow down the microbial digestion of cellulose and fiber in the rumen. Shortages of energy in the form of starch reduce the synthesis of microbial protein. Excess protein reduces the efficiency of energy utilization and increases energy requirements to excrete the excess ammonia. Energy and protein balance should reflect the needs of the rumen and of the cow.

8. *Evaluate rations by the total amount of nutrients they contain, rather than by the percentage.* Incorrect intakes of dry matter will result in nutrient imbalances.

A number of additives are available to help correct a drop in the fat content of the milk. Before using any of these, however, you need to do a little checking.

- Is the problem low milk fat or a shortage of energy?

- Are any of the factors mentioned earlier part of the problem? If so, correct these first.

- Are all of the cows showing lower butterfat tests or only part of the herd?

- At what stage of lactation are the cows with low fat tests?

- How much milk is being produced by those cows?

If the fat-test problem remains, one or more of the following additives could be useful. Consider the cost of the products and the production response; also, check for problems with palatability and a lowered feed intake.

SODIUM BICARBONATE (baking soda) buffers and neutralizes rumen acidity, favors the production of acetate (volatile fatty acid), and helps the growth of microbes in the rumen. Kansas researchers obtained $17 more in milk production for each $1 invested in sodium bicarbonate. The greatest response came during the first 120 days of production, with little response during late lactation. At Pennsylvania State, researchers reported an average of 6.2 pounds more of fat-corrected milk (4 percent) during the first 9 weeks after calving when sodium bicarbonate was fed. The intake of dry matter was significantly higher, too, with 47 percent of the cows on the bicarbonate rations peaking over 80 pounds compared to 26 percent in the control group. Corn silage was the only source of forage. The preventative level is 1 to 2 percent of sodium bicarbonate in the grain mix (or a top-dressing of 2 to 4 ounces per cow per day). To correct a serious drop in milk fat, research results from Wisconsin suggest using a grain mixture with 5 percent sodium bicarbonate. Consider the cost because bicarbonate is 18 to 25 cents per pound. A Minnesota trial reported an average 25 grams of sodium bicarbonate consumed free-choice per cow per day.

BENTONITE is a clay mineral which swells 5 to 20 times in the rumen and has mineral-adsorbent properties. It can correct milk fat depression due to heavy grain feeding by adding bulk, slowing down the rate of feed passage, or affecting the fluid balance in the rumen. Adding 5 percent (100 pounds per ton) in the grain mixture is a corrective level; 2 to 3 percent is a preventative level. Cows may consume large amounts of bentonite when it is offered free-choice (113 grams per cow per day). Bentonite is also used as a binder in pelletizing feed.

MAGNESIUM OXIDE contains 54 percent magnesium by weight. Feeding 0.4 pound per cow per day can correct a milk-fat depression caused by heavy grain feeding. The magnesium oxide increases uptake of milk fat precursors (plasma lipids) at the mammary gland. Since magnesium oxide is unpalatable, using more than 40 pounds per ton in the grain mix can cause a drop in feed intake. A combination of sodium bicarbonate (3 parts) and magnesium oxide (1 part) is more effective than using magnesium oxide alone.

METHIONINE HYDROXY ANALOG (MHA) is a form of the essential amino acid, methionine. MHA provides extra methyl in the rumen, forms phospholipids for fat mobilization in the blood stream, and stimulates the growth of protozoa. Wisconsin researchers reported that no benefit was realized by adding MHA to a ration causing milk-fat depression. However, the fat test increased (from 0.1 to 0.5 percent) when 0.25 to 0.3 percent of the MHA analog was added to a ration low in fiber and protein content. Feeding 25 grams of MHA per cow per day 2 weeks before calving and during the first 120 days of lactation provided the best response.

VERMICULITE, PLASTIC TABS, AND OTHER INERT SUBSTANCES can add bulk to the ration and slow down the rate of passage in the cow's body. However, these materials take the place of nutrients in the dry matter of the ration, so the one benefit can be offset by the other problem.

DRIED WHEY used at 10 percent of the grain mixture partially corrected milk-fat depression. The whey increases the production of butyrate in the rumen and also affects fluid balance and turnover in the rumen.

LIMESTONE (CALCIUM CARBONATE) has been used as a buffer in livestock rations. It seems to function in the small intestine by maintaining a desirable pH for activity by alpha amylase enzymes. Indiana researchers reported an increase in the fat test from 3.69 to 3.86 percent when limestone was added to the diet at 2.71 percent. There was no significant difference in feed intake, milk production, and fat-test percentages. However, the cows fed the limestone supplement gained an average of 1.5 pounds per day, but those on the control diet (without limestone) lost an average of 0.6 pound per day. The fecal pH and fecal starch percentages were 6.13 and 7.69, respectively, compared to 6.57 and 3.01 percent for the control and buffered diets. An increase in the digestion of starch and cellulose occurred in lactating cows.

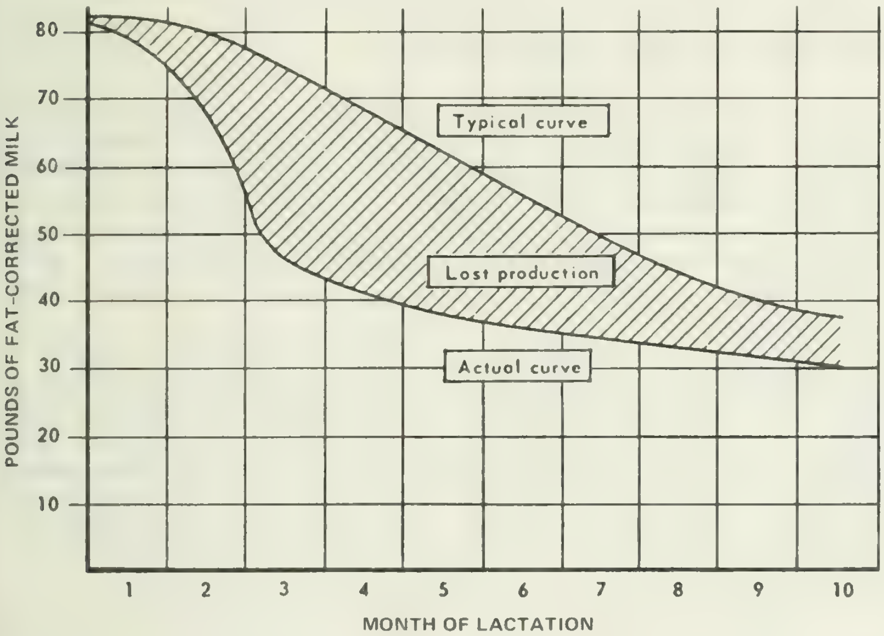


Figure 1. Early lactation drop.

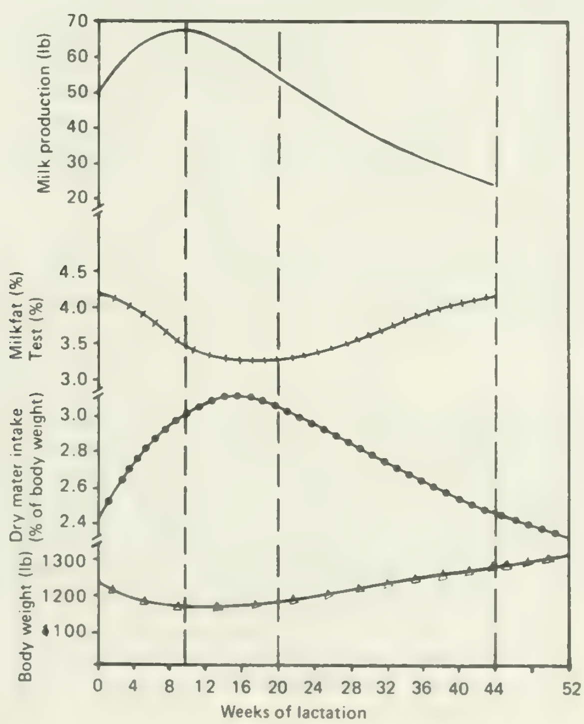


Figure 2. Various curves for changes in milk production, dry-matter intake, and body weight.

Making Money by Using DHIA Records Properly

GARY W. HARPESTAD

DURING 1978, OVER 1,200 ILLINOIS DAIRYMEN invested over $1 million in records. I call this an "investment" because the herds enrolled in the DHI Record Program averaged almost 6,000 pounds per year more milk per cow than the herds not enrolled in any record plan. A conservative value for the additional milk would be $615. The average cost of testing a cow for 1 year is approximately $12. So every dollar invested in records returned $50 in additional milk. Records are an investment, not a cost.

The purpose here is to show dairymen who do have their herds on test how they can obtain the maximum value from their records; also, to show dairymen whose herds are not currently enrolled in a record program how records can be used to improve production and income.

BREEDING AND IDENTIFICATION RECORDS

The DHI program provides the dairyman with a number of ways to keep breeding and identification records. First, members receive a barn wall chart called Breeding and Calving Records (DHIA-208). This chart shows the names and identification numbers for all the cows, printed out by computer. The chart is used to record heat dates, breeding dates along with the service sire, pregnancy status, and calving information. Another DHIA form is the 21-Day Reproduction Record Calendar (DHIA-211) on which heat and breeding dates can be recorded. The next heat date is automatically shown next to the heat or breeding date. The calendar can also be used to determine when each cow should be checked for pregnancy.

For an extra fee of 2 cents per cow-month (30.4 cow-days), cooperators can receive with each monthly report, five different lists of cows. Called the Herd Management Option (DHIA-212), these lists include which cows to breed, to check for pregnancy, and to dry off; also, what cows are due to calve and a list of the low-producing cows according to the dairyman's own specifications. For an additional 2 cents, a sixth list called the Culling Guide will be provided. This is a list of potential cull cows, including the daily profit, profit until due to calve, projected dollar difference from the herdmates' next lactation, and the dollar total.

When a cow is bred, the breeding date and the identification of the service sire are reported. We use the registration, eartag, or AI code number or the short name on the DHIA-217 form (Information on Breedings and Female Offspring). The results of pregnancy checks should also be reported. For each female calf, an eartag should be reported on the DHIA-217 form. The DHIA-217 sheet should be sent in with each Barn Sheet (DHIA 201). The dairyman can have the service sire listed or the action needed (date to breed, pregnancy check, dry off, etc.) printed on the DHIA-200 form. If the service sire is listed, I suggest the dairyman enroll in the Herd-Management Option for the action-needed information.

For each female calf born, a Lifetime History of Individual Cow is issued (DHIA-205). This 8½ by 11 form on heavy paper provides an outline for sketching the calf, a breeding and calving record, and place to record reproductive and health problems. The form is punched so it will fit into the green notebook called the Lifetime Dairy Herd Record.

Twice a year, the dairyman receives a form called Replacement Females (DHIA-219), listing all unfreshened females in the herd. The dairyman should examine this list carefully to be sure that all of the sires are listed as well as the correct identification numbers. Eartag numbers may be changed to registration numbers, and the sires listed by their short name should be changed to a registration or AI code number. The corrected DHIA-219 form is mailed back to the Computing Center where the corrections and additions are entered and a DHIA-220 Replacement Female Evaluation is issued. Replacements are listed by sire, showing the Predicted Difference (PD) of the sire, the Estimated Average Transmitting Ability (EATA) of the dam, and the pedigree estimated breeding value of the heifer. The DHIA-220 form also shows separate averages for replacements under 12 months of age and those over 12 months, enabling the dairyman to estimate the quality of the replacements that will be entering the herd during the next 2 years.

Future plans for the heifer program call for reporting the breeding dates for heifers and listing heifers on the Barn Sheet by when they are due to calve. When this program becomes operational, the supervisor will not have to report the identification information on the back of the Barn Sheet because it will already be in the computer's memory bank.

USING DHIA RECORDS FOR FEEDING

Perhaps the most immediate benefits from using DHI records are the recommendations on how mucn grain to feed. To obtain the most from this part of the program, the body weight of the cow must be reported on the DHIA-217 form at calving time. The amount and kind of forage being fed (hay, haylage, silage, and pasture) must be coded accurately. The DHIA supervisor has the list of codes and has been instructed on how to use them.

The computer determines the feeding requirements from the cow's production and her body weight and according to how much is supplied by the forage. The amount of grain needed to provide the difference between that supplied by the roughage and the total ration requirement is determined and printed out on the DHIA-200 form. Dairymen who are not feeding according to production can save grain and obtain more milk by using these recommendations.

High-producing cows need a ration with more protein than those with lower milk production. If it is possible to separate the cows into high and low groups and feed different grain mixtures to each, the computer will make separate recommendations. The dairyman can list cows by feeding groups (strings) on both the DHIA-200 form and the Barn Sheet. Feeding a high-protein mixture to the high producers can result in greater production and a lower feed bill. Many dairyman save enough money by feeding according to milk production to cover the testing fees.

The Herd Summary (DHIA-202) has two summaries which evaluate the feeding program. The Feeding Summary lists the types and amounts of the various feeds; also, the pounds of milk produced per pound of grain fed. The Cost and Return Summary shows the dollar value of production and the feed per cow as well as for the herd, on sample day and for the year. It also summarizes the feed cost per hundredweight of milk and the return per $1 spent for feed. How does your herd compare to the averages listed in the following table?

Illinois Holstein Herds, May 1978-April 1979 Testing Year

Range in average milk production (lb.)	No. of herds	Feed cost	Value of product over feed cost	Feed cost per cwt. of milk	Roughage rate (%)	Milk-to-grain ratio
10,000 to 10,999	38	$438	$625	$4.19	2.3	2.6
11,000 to 11,999	74	459	720	3.97	2.2	2.6
12,000 to 12,999	105	465	818	3.70	2.1	2.5
13,000 to 13,999	140	481	907	3.55	2.2	2.6
14,000 to 14,999	191	506	984	3.49	2.2	2.7
15,000 to 15,999	158	548	1044	3.54	2.2	2.7
16,000 to 16,999	98	543	1150	3.30	2.1	2.8
17,000 to 17,999	50	614	1186	3.51	2.2	2.7
18,000 to 18,999	25	627	1291	3.37	2.3	2.9

PRODUCTION RECORDS

The amount of milk and fat each cow has produced and the predictions for the end of the 305-day period are listed on the Sample Day and Lactation Report (DHIA-200). A figure called the "Difference from Herdmates" shows how superior or inferior each cow is compared to other cows in the herd. The cows with the lowest predicted 305-day record and largest negative difference from herdmates should be considered as candidates for culling. Dairymen who enroll in the Herd Management Option (DHIA-212) received the "low cost" list based on the predicted 305-day figures, Differences from Herdmates, Daily Income over Feed Cost, or Daily Milk.

Once a year, the Herd Ranking and Summary (DHIA-204) is mailed to each cooperator. The dairyman can have the cows in his herd ranked by their Estimated Producing Ability (EPA) or Estimated Average Transmitting Ability (EATA) for milk or fat. This is yet another way of selecting both the superior cows as well as the candidates for culling.

As each cow completes a record by going dry or leaving the herd, a Pedigree and Performance Evaluation is issued (DHIA-203). This report lists all records completed by the cow and evaluates her on the basis of her EPA and EATA, and her daughters and maternal sisters by their differences from herdmates.

To make the money you invest in DHI records pay off, you have to take advantage of all parts of the program--breeding, indentification, feeding, and production. The DHI Record Program is a good investment that can result in a higher income for dairymen who make use of the records to improve the management of their herds.

FORMS USED IN THE DHIA PROGRAM

DHIA Form No.	Name	Explanation
200*	Sample Day and Lactation Report	List of all cows with sample-day and lactation-to-date production figures.
201	Barn Sheet	Work sheet for recording daily milk status, feed data, etc.
202*	Herd Summary	Shows reproduction identification, plus feed and production summary for the herd.
203	Pedigree and Performance Evaluation	Shows lifetime production. New sheet issued each time a cow goes dry or leaves the herd. Available other times at extra cost.
204	Herd Ranking Summary	Issued once a year. Ranks cows in the herd by Estimated Production Ability or Estimated Average Transmitting Ability.
205	Lifetime History of Individual Cow	Issued at birth for heifer calves. Provides a place to record breeding date, reproduction information, and health problems.
208	Breeding and Calving Record	18 by 22 inch wall chart for recording breeding dates. All cows are listed by the computer once a year.
211	21-Day Reproduction Record	18 by 22 inch chart for recording heat and breeding dates. Shows 21-day periods and when the next heat period may be expected.
212	Herd Management Options	Extra Cost Option. Separate lists for cows to breed, pregnancy check, dry, calve, and "low cows." Also a culling guide.
215	Identification Correction Form	Used to report corrections and additions to identification data.

DHIA Form No.	Name	Explanation
217	Information on Breedings and Females Offspring	For reporting breeding dates, service sire, pregnancy status, identification of offspring, and body weight at calving.
219	Replacement Females	List of all unfreshened females in the herd. Received twice a year.
220	Replacement Female Evaluation	Annual evaluation of all replacement females. Shows the Predicted Difference for the sire.

*Extra copies can be printed and mailed to a different address for $1 per herd for each test.

The Role of DHIA Management

BRUCE O. DOKKENBAKKEN

THE BI-STATE DHIA MANAGER is responsible for all business and service aspects of the Dairy Herd Improvement program in Illinois and Iowa. Administratively, he is responsible to the board of directors of Dairy Lab Services, Inc., in close cooperation with the state DHIA boards of directors and the dairy specialists of the Cooperative Extension Service in Iowa and Illinois.

The purpose of management is to work with dairymen, supervisors, boards of directors, and Extension Service personnel to ensure the uniform and efficient administration and execution of the DHIA program. The object of management, simply stated, is to provide a better DHIA program to more dairy producers.

To upgrade the present DHIA program, we will institute:

1. Uniform enforcement of DHIA rules.

2. Periodic testing of all equipment used in the DHIA program.

3. Continuous evaluation of the performance by supervisors.

4. A quality-control program at the central testing laboratory.

Before expanding the DHIA program to serve more dairymen, we must be sure that member dairymen are aware of the range in the programs and options available to them. The dairyman whose herd is on the DHIA program makes three basic decisions that determine the type of testing program which best fulfills the record needs:

1. Recording the milk weights for one or two milkings per day.

2. Sampling the milk weights for one or two milkings a day, or not at all.

3. Supplying the labor for the weighing and sampling by the dairy producer or the DHI organization.

These decisions determine the type of DHIA test to be used. The following descriptions cover the DHI programs how available.

OWNER-SAMPLER (O-S). The DHIA supervisor provides sample cups, meters or scales, and pickup services to get the milk samples to the laboratory. The supervisor is also available to help interpret the results and answer questions. The dairyman is responsible for the weighing and sampling of the milk on test day. He may choose to weigh and sample the milk twice, weigh twice and sample once, or weigh and sample the milk once. The cost to the dairyman is the same for all three options. The second and third options are preferred by many dairymen for convenience. The owner-sampler program with its three options is the most inexpensive of the DHI programs that include testing for milk fat.

OFFICIAL DHI AND DHIR. DHI records are "official" under this program because all weighing and sampling of the milk is done with approved equipment by a certified DHI supervisor according to a set of Official DHI Rules. Thus, the program becomes more costly than using the owner-sample program but provides the dairyman with official DHI data. Such information can be used for advertising purposes when selling breeding stock. Because the records are official, the data in them are used by the USDA to calculate Sire Summary information. This plan is recognized as "official" by all of the dairy breed organizations and by all members of the dairy industry.

DAIRY HERD IMPROVEMENT REGISTRY (DHIR). This program is for registered cows and is same as the Official DHI Program except for the added requirements of the breed associations and the associated fees. Dairymen with registered cattle in the herd are eligible for DHIR Program. After the dairyman applies and is accepted, copies of his records are sent to the breed association for use in breed improvement and recognition programs. This system adds to the value of registered cattle, especially when combined with the new type and production programs now available to purebred breeders.

SUPERVISED AM-PM. The DHIA supervisor visits the farm for one milking each month to record milk weights and take samples. Test milkings are alternated from morning to evening during successive months. Research at Pennsylvania State University indicates that this program is 99.8 percent as accurate as the Official DHI Program with two milkings per day. The Supervised AM-PM Program becomes an official one if an approved recording device is installed to verify the milking interval. The computer uses the milking interval to adjust the milk and butterfat readings to a 24-hour interval. The cost of the Supervised AM-PM Program is approximately 80 percent of the Official DHI Program.

MILK RECORDS (MR). This is the newest, easiest, and more economical record plan available. As the name suggests, the emphasis is on the amount of milk produced. No samples are taken for fat testing. If the dairyman reports the information from his milk plant tests, herd averages for the fat content of the milk can be calculated, the same as with the other plans. The Milk Record Program has a great potential for improving herd management at a very low cost.

All of the DHI programs offer the same management information. The basic DHIA programs just described are supplemented with an number of options that can provide additional management information for the dairyman. Somatic cell counts and protein testing are available to dairymen on the DHIA program through our laboratory at Dubuque, Iowa. The Verified Identification Program (VIP) enables DHIA members to record the number of grade animals in the herd.

As the DHIA program in Illinois continues to grow, we plan to add progesterone testing for pregnancy and forage testing. These options will be available through the DHIA supervisors.

Intertwined with the improvement of services to DHIA members is the expansion of the DHIA program to serve more dairymen. We already have a good program for herd management. As the overall DHIA program continues to improve, we believe that dairy producers who have been properly exposed to the program will want to become DHIA members. The job of the supervisors, with strong support from member dairymen, Extension Service personnel, and DHIA management, is to see that professional dairymen who are not on the DHIA program are made aware of its advantages. Potentially, member dairymen are the best salesmen for the DHIA program. A good word about the DHIA program and the supervisor by a DHIA member can convince someone who is not a member to join.

COST OF THE DHIA PROGRAM

This, too, is a major concern of management. Group purchases of supplies, parts, and equipment will help reduce and stabilize non-labor costs. Redistribution of the equipment used in the program and a better scheduling of labor can also help streamline the operation and benefit the DHIA program. Management will gradually take over the day-to-day operations of DHIA, allowing the Extension Service personnel to concentrate on educational programming, troubleshooting, and providing additional service to the members. The state DHIA management also encourages supervisors to do professional work by providing opportunities for greater income, for advancement, and for the recognition of outstanding service.

The last task for management at the state level is the most important one. That is for the state organization to serve as a communications base for the DHIA program as a whole--including dairymen, supervisors, agri-business people, Extension Service personnel, lab personnel, and the national DHIA organization. As the DHIA program in Illinois continues to grow, state management and coordination of the program will become increasingly important.

Protein Feeding for Top Production

JIMMY H. CLARK

A BALANCED DIET that contains the required nutrients must be fed in liberal quantities if maximum milk production is to be obtained at an economical cost. Crude protein is an essential ingredient in the ration of dairy cattle. During the past 10 years, we have come to recognize that both the amount of crude protein and the quality of that protein are important in formulating rations for dairy cows.

We have conducted several studies to gain more information about the amount and kind of crude protein that should be fed to dairy cows. Results of one of those studies are shown in Table 1. Fifty cows were divided into 5 groups of 10 cows each and fed rations containing 10- to 14-percent crude protein. Soybean meal, urea, or a mixture of the two were used as sources of supplemental crude protein in the rations that contained crude protein at 12 and 14 percent, respectively. Cows fed the ration that contained 10-percent crude protein without supplemental crude protein produced an average of 10,284 pounds of 4-percent, fat-corrected milk (4% FCM) during the 310-day lactation. The production of 4% FCM was increased to 13,073 and 12,808 pounds, respectively, when the crude-protein content of the ration was increased to 12 percent by adding either urea or soybean meal. When the crude protein in the ration was increased from 10 to 14 percent with a mixture of urea and soybean meal, the production of 4% FCM increased to 14,304 pounds. However, using only soybean meal to raise the crude-protein content of the ration to 14 percent resulted in an additional 1,139 pounds of 4% FCM, compared to feeding the mixture of urea and soybean meal.

Table 1. Effect of the Level and Source of Crude Protein on Production of 4-Percent, Fat-Corrected Milk

Percent crude protein in total ration (dry matter)	Source of supplemental crude protein	Pounds of 4% FCM in 310 days
10	None	10,284
12	Urea	13,073
12	Soybean meal	12,808
14	Urea plus soybean meal	14,304
14	Soybean meal	15,443

These results indicate that urea is equivalent to soybean meal when used to increase the crude protein content of the ration up to 12 percent. However, the feeding value of urea is not as great as for soybean meal when the crude-protein content of the total ration dry matter is 13 to 14 percent.

This study as well as others show that substituting urea or nonprotein nitrogen compounds for plant sources of protein (soybean meal) in rations where the amount of crude protein required is greater than 13 percent lowers the milk production from high-producing cows. Urea is used most efficiently when small quantities are added to diets that are low in protein and high in energy content. The efficiency of utilization drops with increases in the amount of urea or of crude protein in the ration and with decreases in the energy content of the ration.

Urea adds only nitrogen to the ration. By contrast, natural protein such as soybean meal supplies nitrogen, energy, and minerals to the dairy cow. Therefore, the only reasons for substituting nonprotein nitrogen such as urea for plant sources of protein in a dairy ration would be an economic advantage or in case of a protein shortage.

REQUIREMENTS FOR TOP PRODUCTION

1. DURING EARLY LACTATION, FEED ALL OF THE ENERGY THE COWS WILL CONSUME. A maximum energy intake is normally obtained by feeding 55 percent of the dry matter as concentrate and 45 percent as roughage.

2. THE DRY MATTER IN THE RATION SHOULD CONTAIN 14 TO 16 PERCENT CRUDE PROTEIN DURING EARLY LACTATION. Over the last half of lactation, the crude-protein content of the dry matter in the ration can be reduced to 12 or 13 percent. The amount of crude protein to feed will depend on the level of milk production, the price being received for milk, and the cost of the protein supplement.

3. DO NOT FEED NONPROTEIN NITROGEN SUCH AS UREA WHEN THE REQUIREMENT OF THE COW FOR CRUDE PROTEIN CANNOT BE MET WITH A RATION CONTAINING 13-PERCENT CRUDE PROTEIN. If economical, urea or other nonprotein nitrogen sources can be added to the concentrate mixture or to corn silage during the last part of the lactation period when the milk yield is less than 45 pounds a day. The urea should not exceed 1.5 percent of the concentrate mixture or 10 pounds per ton of the corn silage. Do not add urea to both the concentrate mixture and corn silage at the concentrations just listed. Urea should be thoroughly mixed with dietary ingredients before feeding. Inadequate mixing can cause problems of reduced feed intake and toxicity.

Blood Testing–A Way of Identifying Problems

CARL L. DAVIS AND LARRY J. THOMPSON

DURING THE PAST 10 YEARS, considerable interest and research has been directed toward developing "blood tests" to help identify nutritional or health problems in dairy herds. The idea originated in England. There, blood was obtained from cows in so-called "well-fed and well-managed herds," which supposedly were "problem-free," and the levels of certain components were measured (blood sugar, protein, urea, hemoglobin, red blood cell count, calcium, phosphorus, and so on). The concentration of these blood components found in the cows from the "problem-free" herds were used as "normal" values for comparison with others.

Blood values of components from cows in so-called "problem" herds that were lower or higher than those from the "normal" cows supposedly indicated certain nutritional inadequacies. For example, if the level of blood sugar from cows in problem herds was lower than that in the "normal" cows, this was interpreted as an indication that the cows in the problem herd were not being fed enough energy. Urea levels outside the "normal" values supposedly indicated that too little or too much protein was being fed.

The idea sounded great, and the early reports certainly led many people to believe that such a program of blood testing would identify the causes of problems such as low production, infertility, a high incidence of metabolic disorders, as well as several others.

A major criticism of the early work, and much of the later work, was that no attention was paid to what the cows were being fed, especially the amounts of each type of feed and of each nutrient. Also, the early workers did not sort out the importance of factors other than feed that would affect the levels of the components in the blood being measured. Such things as the stage of lactation, level of milk production, age of the cow, season of the year, and breed of the cow all affect the levels of various components in the blood.

Recognizing some of the major shortcomings of the early work, we set about assessing the real worth of "blood testing" as a way of helping dairymen solve problems encountered in their herds. Working with researchers in the College of Veterinary Medicine, the cooperation of 9 Illinois dairymen was obtained (5 "normal," well-managed herds, 4 "problem" herds).

There were 5 Holstein herds, 2 Jersey herds, 1 Guernsey herd, and 1 Holstein-Brown Swiss herd in the study. Twenty-one cows in each herd were sampled at each visit to the farm (7 high-producing cows, 7 low-producing ones, and 7 dry cows). The number of visits to each farm varied from 1 to 8. Samples of all feed and water were gathered during each visit. Data on the amounts of each feed being fed were provided by the dairyman.

Blood samples were analyzed for: glucose (sugar), urea, total protein, hemoglobin, red blood cell volume, calcium, phosphorus, and magnesium. Feed samples were analyzed for dry matter, acid detergent fiber, crude protein, calcium, phosphorus, and magnesium. From these data and the estimated weights of the cows (body tape) and level of production, the status of the cows concerning energy, protein, calcium, phosphorus, and magnesium was assessed.

The study showed that the herd where the samples came from had a significant effect on all blood components measured. To put it another way, the cows in herd A can differ significantly from those in herd B and yet both can be considered "normal" in terms of the concentration

of a component in blood. The season of the year when the samples were taken had a significant effect on all blood components, except calcium. The level of milk production affected the concentration of blood glucose (sugar), calcium, and hemoglobin.

What are the practical conclusions from this study? (1) Measuring blood sugar (glucose) levels to gauge whether the cow is consuming adequate energy does not work. The level of blood sugar is closely regulated by the cow's hormones. That level gets out of bounds only in extreme cases. For example, we used a computer to calculate how much we would have to underfeed a cow on energy before the blood glucose would drop to a level that would be considered abnormal. The answer was to feed her only half of the energy she needed. If we did this to the best-producing cow in your herd, you wouldn't need a blood sample to tell you something was wrong with her. (2) The same thing goes for protein and minerals. The blood levels of protein or urea are not good indicators of whether the cow's protein needs are being satisfied.

Does this mean that nothing is to be gained from "blood testing"? Yes and no. The technique as first envisioned did not do the job. However, we are not ready to scrap the idea because there may well be some practical applications if such testing is used in a very judicious way. For example, instead of sampling all of the cows in a herd, attention should be focused on the top producers. These are the cows that are most likely to develop problems under substandard feeding or management practices. So during the past 2 years, we have been working with Dr. Dave McQueen in the College of Veterinary Medicine doing a field study (as well as a study using cows in the University herd) to monitor the metabolic changes that high-producing cows undergo as they move from the dry state into a lactating period and up to the time they hit their peak in milk production. In addition to measuring the blood components already mentioned, we are looking at free fatty acids in the blood and attempting to relate changes in these to the cow's energy status.

We would expect a cow consuming less energy than she needs to exhibit higher levels of free fatty acids because these are produced by the fat breakdown in the body. Also, we are sampling the rumen (paunch) in an effort to relate unusual changes in the microbial fermentation to problems that may develop in the cow.

It is too early to draw definitive conclusions, but the preliminary information indicates that certain changes in the blood and the rumen may be good signs that the cow is on the brink of developing a serious problem. On several occasions after processing the samples obtained from cows in a good Holstein herd, the farmer has been notified that a certain cow should be watched closely for signs of a specific problem that seems likely to develop. We were told shortly thereafter that the cow did exhibit physical symptoms of the disorder.

In the near future, we hope the present study will provide the basic information about the value of "blood testing," especially for high-producing cows during the times of greatest stress. If the results of a few tests can alert the dairyman that a particular cow is approaching a "danager zone," he may be able to keep a major problem from developing.

The Feeding Value of High-Lysine Corn for Lactating Cows

SHEILA M. ANDREW, JIMMY H. CLARK, AND CARL L. DAVIS

CORN AND CORN SILAGE are used extensively for feeding dairy cows. These feeds are excellent sources of energy. However, normal hybrid corns are low in protein; also, the protein they contain is deficient in two amino acids, lysine and tryptophan. Therefore, diets that contain large amounts of corn must be supplemented with a high-protein feed such as soybean meal in order to provide adequate amounts of protein, lysine, and tryptophan.

Although corn hybrids with more than the normal content of lysine and tryptophan have been developed, the feeding value of high-lysine corn for lactating dairy cows had not been tested. Therefore, high-lysine corn and regular corn were grown on the University farm to use in such a test. The yields of dry matter and crude protein from corn and corn silage were similar for both the regular corn and the high-lysine corn.

Forty Holstein cows in the University herd were used in a 112-day lactation trial to compare the feeding value of high-lysine corn and corn silage to that of regular corn and its silage. Ten cows were assigned to each of the following treatment groups: (1) regular corn and regular corn silage; (2) regular corn and high-lysine corn silage; (3) high-lysine corn and regular corn silage; and (4) high-lysine corn and high-lysine corn silage.

Milk production, milk fat percent, and milk protein percent did not differ significantly among the four treatment groups. (See the accompanying table.) Furthermore, the type of corn fed did not significantly affect feed intake or the efficiency of feed conversion to 4-percent, fat-corrected milk. The results indicate that the feeding value of high-lysine corn is similar to that of regular corn for the production of milk, milk fat, and milk protein by dairy cows.

Average Daily Intake of Dry Matter, Milk Yield, and Milk Composition by Dairy Cows Fed High-Lysine or Regular Corn

	Regular corn		High-lysine corn	
	Regular corn silage	High-lysine corn silage	Regular corn silage	High-lysine corn silage
Dry matter intake (lb./day)	41.9	44.7	43.4	42.7
Milk yield (lb./day)	62.1	63.2	63.0	67.2
Milk protein (%)	3.23	3.22	3.42	3.34
Milk fat (%)	3.31	3.26	3.37	3.13

The Action of Anaerobic Bacteria in the Rumen and of Other Bacteria

ROBERT B. HESPELL AND MARVIN P. BRYANT

DIVERSE LINES OF RESEARCH ARE BEING CARRIED OUT IN OUR LABORATORIES, at present dealing mainly with the activities of anaerobic microbes.[1] Ten graduate students and postdoctoral research assistants are investigating the:

1. Production of methane gas from animal wastes.
2. Anaerobic degradation of fatty acids.
3. Survival of rumen bacteria.
4. Anaerobic fermentation of methanol.
5. Effects of monensin on the growth and metabolism of protein-splitting rumen bacteria.
6. Regulation of the growth and enzymes associated with the assimilation of ammonia and other nitrogen compounds by bacteria in the rumen.
7. Growth of cellulose-digesting rumen bacteria.
8. Activities of the protein-splitting enzyme found with the intracellular growth of soil bacteria.

For brevity, the first three will be discussed here.

The present energy crisis requires the development of alternate sources of energy to replace fossil fuels, which will become depleated in the near future. Among the alternatives, the bioconversion of animal wastes carries a high potential for success.

[1]Some of our research efforts are of an applied nature, providing information directly applicable to practical dairy problems. However, many of our research efforts are laboratory studies dealing with basic biological concepts. Such research provides the necessary information and insights for understanding a biological process and for future studies of dairy cows by microbiologists and nutritionists. For example, our past and present studies on the microbial processes associated with the digestion in the rumen of organic dietary compounds by dairy cows have contributed in major ways and continue to do so to our understanding of similar processes in other ruminants, in nonruminants (such as horses, pigs, and humans), and in the sediments of lakes and sewage-treatment plants.

Approximately 2.2 billion tons (2 billion metric tons) of animal wastes (solids) are generated in the United States each year. About half of this waste comes from intensive systems of animal production. Thus, the anaerobic bacterial fermentation of cattle waste is attracting considerable attention, not only in terms of waste management but also in terms of producing methane (biogas) plus fertilizers and protein-rich supplements for animal feeds from the fermentation byproducts.

The rate-limiting reactions in methane fermentation involve the degradation of fatty acids. Our experiments have been conducted in the laboratory using small, bench-top fermentors that are "fed" once a day with manure wastes obtained from cattle being fed a high-concentrate diet. The rates of degradation for acetate, propionate, and butyrate have been recorded.

Our results show that acetate is quantatively the most important acid for conversion into methane, accounting for 72 to 85 percent of the methane produced. Waste fermentations with methane production at 104° F. (40° C.), mesophilic, and at 140° F. (60° C.), thermophilic, have been studied in separate fermentors. With both, the fermentation was initiated by the bacteria normally present in the wastes.

After steady-state conditions were reached, methane production was 35 percent higher in the thermophilic fermentor than in the mesophilic one using the same substrate under identical loading conditions (6 percent organic matter in the daily "feeding," with a 10-day turnover time). Under lower loading conditions (4 percent organic matter and a 13-day turnover), the production of methane in the thermophilic digestor was only 15 percent higher than in the mesophilic digestor.

These data along with our previous studies indicate that more rapid methane production with higher loading rates and shorter turnover times can be realized. Thus, smaller fermentors with greater stability could be used with the thermophilic process, reducing the capital costs of methane production and permitting the development of small-scale fermentor systems on the farm.

The recently renewed interest in methane fermentation stems mainly from the potential of that process for converting large quantities of organic material into methane, an energy-rich fuel. Such organic resources include animal manures, other agricultural byproducts, and the wastes from municipal treatment facilities.

The fermentation process was thought to involve two major metabolic groups of bacteria. Recently, however, we have discovered and characterized several previously unknown species of bacteria. They belong to a third major metabolic group known as the hydrogen-producing (or protein-reducing) acetogenic bacteria. These bacteria are essential for the anaerobic degradation of organic matter because they degrade the propionate and longer-chained fatty acids, important intermediates in the process.

One species of the hydrogen-producing acetogenic bacterium, *Syntrophomonas wolfeii*, degrades butyrate and several other fatty acids into acetate and hydrogen. These degradations and the growth of the organism take place only when the hydrogen produced is utilized rapidly and completely by other bacteria, such as those that produce methane. Even extremely low levels of hydrogen inhibit the process.

Our work emphasizes clearly the: (1) importance of methane-producing bacteria in removing hydrogen from anaerobic systems, so both anaerobic degradation of organic matter and methane production can occur; and (2) key role of hydrogen in regulating efficient methane production.

The response of rumen bacteria to starvation is another type of research being conducted in our laboratories. When cows are fed once or twice a day, some metabolic groups within the rumen may undergo starvation. After feeding, the number of bacteria capable of metabolizing only a specific component in the feed will increase, following the pattern of fermentation for that substrate. As fermentation continues, however, those bacteria start to die for lack of food. After most of the dietary starch is fermented, for example, many of the starch-degrading bacteria may starve to death. Enough must survive, though, to efficiently degrade the starch in the next feeding.

We have used two approaches to determine the survival of rumen bacteria. For one, we use washed cell suspensions of mixed bacterial cells obtained for contents taken from the rumen

of the animal. For the other, we use washed cell suspensions of a single species obtained from highly controlled growth conditions in the laboratory (*in vitro*). Both types of cell suspensions are then subjected to starvation conditions with no nutrients available. Numerous metabolic and physiological aspects are monitored.

This research is still in the early stages, but some tenative conclusions can be drawn:

1. Rumen bacteria under total nutrient-starvation conditions in the laboratory have an extremely poor capacity to survive. Within the first 2 hours, 60 percent or more of the initial population will die.

2. The bacteria that utilize large polymers, such as the cellulose and glycerol fermentors, seem to have a better capacity for survival than those that utilize soluble carbohydrates.

3. All cellular components seem to be degraded by the rumen bacteria during starvation, apparently in an effort to stay alive by degrading "nonessential" cell constituents.

We plan to determine the succession of the various metabolic groups in the animal after once-a-day feeding. We also hope to assess the influence of changes in the diet on the metabolic makeup of the microbial population in the rumen. With such information, new diets might be formulated or changes made in the frequency of feeding. This would help minimize the starvation of bacteria in the rumen and maximize the microbial growth yields, thus improving the use of feed.

Feeding and Management in Illinois DHI Holstein Herds

MOHEMMAD A. WAHEED, ANDREW J. LEE, AND GARY W. HARPESTAD

FEEDING AND MANAGEMENT PRACTICES vary in Illinois DHI herds, but how this affects the milk yield of dairy cows had not been examined. In the fall of 1974, information about 20 feeding and management practices was collected from 741 DHI dairy herds of Holsteins in Illinois. The DHI supervisors cooperated in the process of collecting data. First-lactation milk yields for registered and grade Holstein heifers freshening in 1973 were obtained from DHIA computer files.

FEEDING AND MANAGEMENT PRACTICES

Stanchion and free-stall barns were the types of housing used in 39 and 35 percent of the herds, respectively. In 12 percent of the herds studied, the cows were kept in loose housing. The remaining herds were in combination-type housing.

The sources of roughage for the lactating herd during the winter were: corn silage and hay, 57 percent; corn silage, hay, and haylage, 21 percent; corn silage and haylage, 7 percent; hay and haylage, 3 percent; hay only, 5 percent; and corn silage only, 4 percent. During the summer, the roughage was supplemented by pasture grass or green-chop forage in 62 percent of the herds. For first-lactation heifers, the levels of grain fed per day according to milk production were: 11 pounds of grain for up to 23 pounds of milk; 15 pounds for 23 to 50 pounds of milk; and 20 pounds of grain for 50 to 75 pounds of milk. As the heifers grew older, the number of dairymen who fed no grain increased. During the last 2 months of pregnancy, the heifers were fed 4 to 11 pounds of grain per day.

The decision of when to breed the heifers was governed by three principal factors. Age, condition, and size were considered as important by 73, 83, and 96 percent of the dairymen in the study, respectively.

When the data were grouped by the DHI regions of Illinois, we found that many feeding and management practices varied by the region of Illinois, including types of housing, sources of roughage for lactating cows in the summer and the winter, the amount of grain fed to lactating cows and to heifers from 12 months of age to 2 months before calving, sources of roughage for the heifers during the winter, and the ideal age and weight at which to breed the

heifers (Table 1). Other practices were followed equally in all regions of the state, including the amount of grain fed to heifers that were 6 to 12 months old and the grain given to them during the 2 months before calving.

Table 1. Distribution of Some Important Feeding and Management Practices, Illinois, DHI Records, 1974

	Percent of herds by regions			Percent of all herds
	Northwest	Central	Southwest	
SOURCE OF ROUGHAGE FOR THE MILKING HERD DURING THE SUMMER				
Haylage only	13	11	8	11
Hay only, or with haylage	10	7	17	10
Corn silage only, or with hay and haylage	12	25	24	17
Pasture, greenchop, or both	10	13	2	10
Pasture or greenchop, or both with corn silage	6	6	2	5
Pasture or greenchop, or both with hay or haylage, or both	32	22	21	28
Pasture or greenchop, both with hay or haylage, or both with corn silage	16	14	19	16
Other sources	1	2	7	2
AMOUNT OF GRAIN FED TO HEIFERS 12-18 MONTHS OF AGE (LB.)				
No grain	28	23	8	24
1 to 4	36	43	49	40
4 to 11	31	30	40	32
Over 11	5	4	3	5
AMOUNT OF GRAIN FED TO HEIFERS DURING 2 MONTHS BEFORE CALVING (LB.)				
No grain	19	20	9	18
1 to 4	22	25	19	23
4 to 11	44	43	57	45
11 to 15	11	10	13	11
Over 15	4	2	2	4
IDEAL WEIGHT FOR BREEDING HEIFERS (LB.)				
500 to 650	7	4	2	6
650 to 800	57	56	81	60
800 to 950	32	34	17	31
Over 950	4	6	0	4

Cows in stanchion barns were fed roughage and grain individually. Lactating cows in stanchion barns were fed more grain than those in loose housing. Dairymen seem to feed grain to lactating cows according to their milk production. The lactation number does not appear to be important in that consideration. As the milk yield increased to 50 pounds per day, the amount of grain fed also went up. Cows producing more than 50 pounds were given the same amount of grain as those yielding 50 pounds, showing a leveling-off of grain feeding at the higher levels of milk production.

FACTORS AFFECTING MILK YIELDS

The 20 practices examined in this study explained only 24 percent of the variation in milk yields among the herds. Other practices, such as health management and feed quality, may explain the remainder.

Heifers fed no grain between 12 and 18 months of age produced an average of 315 pounds more of milk than those fed 4 to 11 pounds of grain per day. Feeding grain at that age probably caused excessive fattening which, in turn, reduced milk yields. Feeding grain during the last 2 months of pregnancy is a recommended practice because additional nutrients are required then for the growth of the unborn calves. Heifers fed 1 to 4 pounds of grain per day durin

the last 2 months of pregnancy produced an average of 475 more pounds milk than those given no grain. The heifers bred at higher body weights produced more milk than those bred at lower weights. If breeding at a higher body weight is accomplished by delaying the breeding, however, that will not be profitable.

RANKING SIRES ACCORDING TO DIFFERENT FEEDING AND MANAGEMENT PRACTICES

An important consideration in selecting sires for breeding is whether they rank the same in terms of feeding and management environments. Our results suggest that the sires ranked almost the same according to different sources of roughage used for the lactating herd during the summer, various levels of grain fed to the heifers 12 to 18 months of age as well as during the 2 months before calving, and by different body weights for the heifers when they were bred.

The Implications for Human Health of Orotate in Bovine Milk

ROBERTA P. DURSCHLAG, BARRY W. JESSE, AND JAMES L. ROBINSON

OROTATE, A NATURAL METABOLITE FOUND IN COW'S MILK, represents a potential human health hazard. When rats consume a diet with 1 percent orotate (also known as orotic acid), they develop a severely fatty liver within a week. Since cow's milk and milk products are the main sources of orotate in the human diet, questions are raised periodically about the safety of orotate in bovine milk.

The purpose of this research was to assess the seriousness of the problem. A two-pronged approach was used, to determine: (1) the levels of orotate in the milk of dairy cows and (2) the metabolic effects of orotate consumption in various species.

OROTATE IN COW'S MILK

Orotate concentrations in the morning milk of all 250 lactating cows in the University of Illinois dairy herd are shown in Figure 1. The average was 81.1 micrograms per milliliter (μg/ml), which is virtually the same as the 80 micrograms per milliliter found in market milk. At this concentration, orotate accounts for about 0.1 percent of the total nonfat milk solids. The variation in orotate concentrations was surprisingly large between animals. Major milk components such as protein and fat usually do not show such variability, although concentrations of lactoferrin, another minor milk component, also vary widely.

Orotate in the milk of the three cows with the lowest levels never exceeded 40 micrograms per milliliter during a five-month period. By comparison, concentrations were exceptionally high for two cows: cow 2,778 had 664 micrograms per milliliter and cow 3,365, 346 micrograms per milliliter.

The herd survey revealed differences in orotate concentrations attributable to breed. Milk from Guernsey and Jersey cows contained less orotate than did milk from Holstein-Friesian, Ayrshire, and Brown Swiss cows. These differences will have to be verified with a larger sample of non-Holsteins, which constituted only 20 percent of the animals surveyed.

We also studied the effect that the stage of lactation has on orotate secretion in Holstein-Friesians. At the outset of lactation the concentrations were very low, first-drawn colostrum containing about 10 micrograms per milliliter (Figure 2). In subsequent milkings, the level rose until it reached 76 micrograms per milliliter by the tenth week. This level was maintained until week 38, when it started to decline. Milk production followed the expected pattern, peaking by the eighth week.

Because of her unusually high orotate secretion, cow 2,778 was of particular interest and was studied throughout an entire lactation. At all stages, her milk contained levels 4 to 10 times higher than those of the other cows in the herd. During the ensuing dry period, her lacteal secretions contained 35 micrograms per milliliter, compared to 5.7 in the others. Throughout the next lactation, her milk orotate was similarly elevated.

Our findings for cow 2,778 suggest that these high concentrations are a persistent characteristic of this cow. None of her maternal or paternal half-sibs that we have been able to test produced milk with high orotate levels. In December, 1978, cow 2,778 gave birth to a female calf. We are eagerly awaiting her first lactation to see if she, too, will have high levels in her milk.

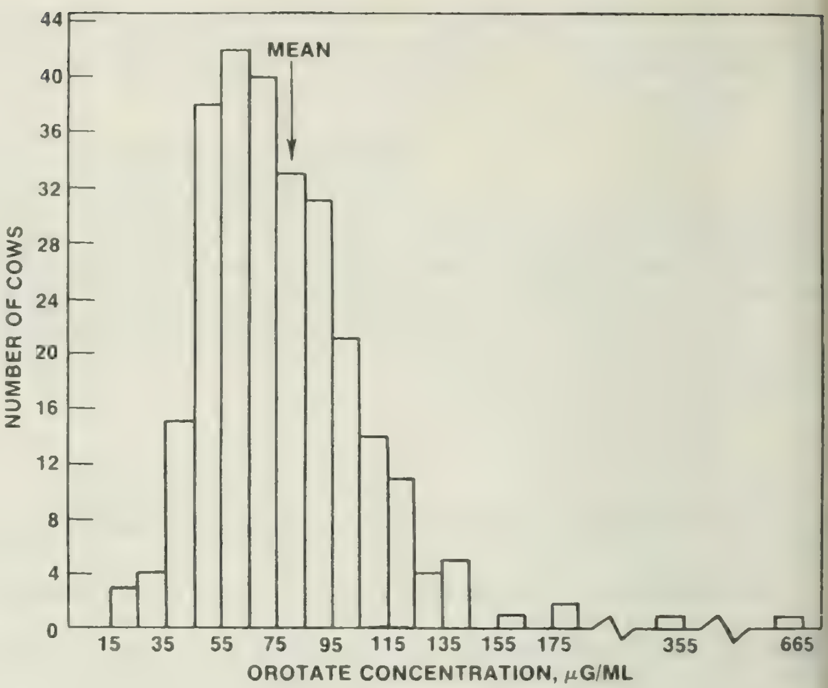
METABOLIC EFFECTS OF OROTATE

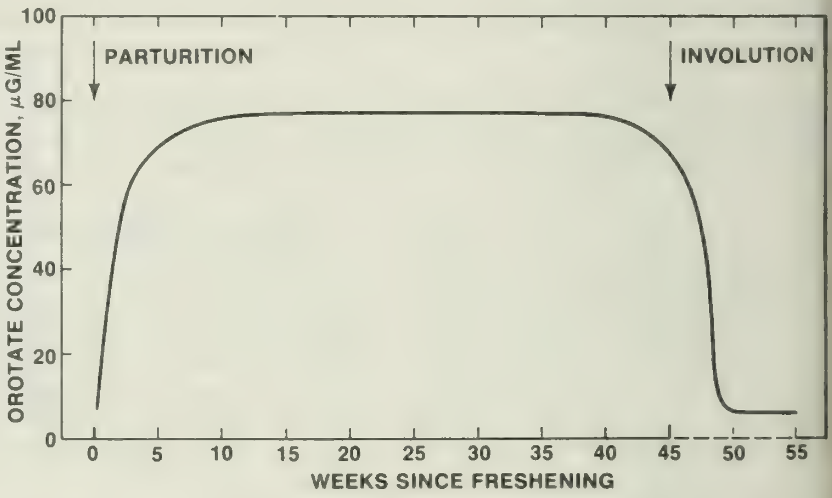
It has long been known that abnormal levels of fat accumulated in the livers of rats that have been fed orotate at 1 percent of the diet. We determined the minimal levels of dietary orotate and the number of feeding days necessary to induce a fatty liver.

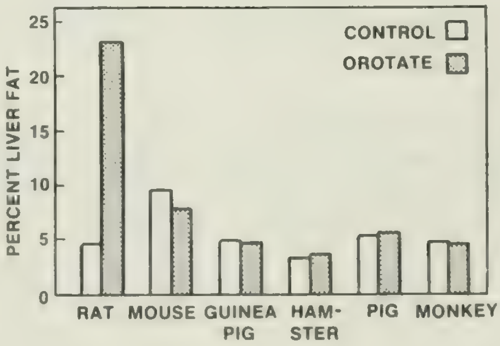
Fed at 1 percent of the diet, orotate led to a fatty liver in rats by the seventh day; no fat was observed on the third day. (The rats were not examined on days 4, 5, and 6.) However, the rats were receiving 10 times the level normally found in pooled commerical milk, which contains only about 0.1 percent orotate in the nonfat solids. At this lower level, no fat was observed by the tenth day, but some had accumulated by then when orotate was fed at 0.5 percent.

The effect of feeding orotate at 1 percent of the diet to various species is shown in Figure 3. Of the 6 species studied, only rats developed a fatty liver; mice, guinea pigs, hamsters, pigs, and monkeys were not affected significantly.

Additional studies comparing rats, which are susceptible, and mice, which are not, suggest possible reasons why certain species would respond differently. After feeding, mice accumulated less orotate in their livers and excreted it in the urine much more rapidly than rats. Furthermore, after orotate ingestion, mice showed a less severe change in the levels of liver purines and pyrimidines (critical cellular metabolites), a response that may protect mice from developing fatty livers.







At top, distribution of milk orotate levels among 250 dairy cows. (Fig. 1)

Center, variation in milk orotate during lactation in 8 Holstein-Friesian cows. (Fig. 2)

Bottom, species specificity of fatty liver induced by orotate at 1 percent of the diet. (Fig. 3)

EFFECTS ON HUMANS

Our findings indicate that orotate probably does not pose a health hazard to adult humans. Although our investigations were limited to 6 nonhuman species, the fact that only rats

developed fatty livers argues against the possibility that humans would do so, too. In the typical adult diet, orotate constitutes only 0.005 percent of the total solids, a value at which even rats show no liver changes.

Human infants on a basic diet of cows' milk receive about 0.1 percent orotate, which was too low to produce significant liver changes in any of the species we examined, including rats. Both rats and mice showed some changes in their purine and pyrimidine levels when orotate was fed at 1 percent of the diet. It is reasonable to predict from our findings that infants will experience no serious effects from the low concentration of orotate found in cows' milk.

More Offspring From Our Better Cows

CHARLES W. GRAVES

THE AVERAGE DAIRY BULL IN AI SERVICE produces approximately 7 billion sperm per day. Using routine dilution and storage procedures, that is enough for more than 182,000 inseminations per year from 1 bull.

The gamete-producing ability of the female is much different from the sperm production of the male. A cow normally ovulates 1 oocyte (egg) per 21-day estrous cycle. If not inseminated, she should ovulate about 17 oocytes a year. If she is to deliver 1 offspring each year, she will produce many fewer oocytes. By contrast, the male constantly produces new spermatozoa each day. The female is born with a definite number of oocytes, though, and no new ones can be produced. Although the total number of oocytes present in a calf at birth is several hundred thousand, fewer than 170 of them usually will be ovulated in the 10-year reproductive life of the cow.

Research in the Department of Dairy Science now indicates that it may be possible to greatly increase the number of oocytes obtained from a cow, therefore increasing the potential number of offspring from the better animals. We used two techniques, superovulation and oocyte maturation.

In the superovulation experiments, each cow was superovulated 5 times, the first 3 times at 14-day intervals. For the fourth and fifth times, the cows were allowed to ovulate once without superovulation and then they were superovulated starting on day 12 after estrus. Because of the possible damage that could occur to the cows from repeated surgical recovery of the embryos, all of the embryos were recovered without surgery. Two sources of superovulating hormones were used, Pregnant Mare Serum Gonadotropin (PMSG) and Follicle Stimulating Hormone (FSH). Ovulation was induced with prostaglandin $F_2\alpha$.

The responses to the superovulatory treatment varied greatly, by individual cows and between cows, with zero to 78 embryos being recovered from 1 cow at 1 superovulation period. The palpation of the ovaries when the embryos were flushed out indicated that between 40 to 60 percent of the ova that were ovulated were recovered as embryos 6 to 8 days after estrus. That percentage of recovery for embryos based on the number of ova ovulated is low, but is similar to reports from commercial embryo-transfer units. The cause is due in part to the inaccuracy involved in counting the ovulation points, or corpora lutea. The count must be accomplished by palpation through the rectal wall.

At the first superovulation for each cow, an average of 15 ova were ovulated with 7 embryos recovered. There was no statistically significant difference between FSH and PMSG treatments. The respective figures were 17.9 and 13.9 ova ovulated and 6.7 and 6.9 embryos recovered.

At the second and third superovulatory attempts, significantly fewer ova were ovulated and fewer embryos were collected compared to the first superovulation. It was also very difficult to synchronize the cows and accurately pinpoint the time of ovulation during the second and third superovulation attempts when the interval from the previous superovulation was only 14 days. Often, these cows did not return to estrus for up to 10 days after the prostaglandin treatment, even though an analysis of the milk showed that progesterone was absent and that the corpord lutea were not functioning.

At the fourth and fifth superovulations for each cow, when the interval from the previous superovulation was at least one estrous cycle, the number of ova ovulated determined by the number of corpora lutea and the number of embryos recovered increased to the figures obtained in the initial superovulation.

In order to determine whether the cows were slowly becoming refractive, or nonresponsive, to the repeated use of the same injected hormones, the hormones were reversed, that is, those cows being superovulated with FSH were switched to PMSG and vice versa for another superovulation attempt. In terms of the number of ova ovulated and the number of embryos recovered, the results were similar to those obtained in the previous superovulation attempt, when the cows had been superovulated 4 consecutive times with the same hormone. The blood samples taken from the cows at each of the superovulations and tested for the presence of antibodies by bioassay as well as immunoassay showed that no antibodies had built up in the blood stream against the injected hormones.

The results of these studies indicate that the cow can be superovulated several times without showing a decrease in the number of ova ovulated. These results contradict the conclusions reported in several earlier studies, in which for some reason a decrease in ovulatory response was noted. Although we have not shown that a cow can be superovulated repeatedly throughout her lifetime, we did establish the fact that a cow can be superovulated several times within a relatively short period and then become pregnant and produce 1 offspring per year on her own. With 4 or 5 superovulations per year, each cow should produce 35 to 50 additional embryos per year. These could be frozen and subsequently transferred nonsurgically to other cows that would serve as incubators.

The second technique being studied in an effort to increase the number of offspring is oocyte maturation. Under this procedure, a small portion of an ovary containing several thousand oocytes is removed and the oocytes are recovered and matured *in vitro* (outside the cow) under the influence of hormones. After the oocytes have matured, they can be frozen for later use or fertilized *in vitro* and the embryos cultured to the blastocyst stage. At that time, they can be frozen or transferred immediately to a recipient. The latter procedure has been carried out successfully in our laboratory with rodents and is now being adapted for use with the cow.

By using the procedures described, we hope to greatly increase the number of offspring produced from our high-producing cows. Other procedures under study in our laboratory, such as sexing of the embryos, may also help increase the production and reproduction within our dairy herds.

The University Modernizes Its Dairy Facilities

SIDNEY L. SPAHR

MAJOR CHANGES ARE TAKING PLACE in the University of Illinois facilities for housing dairy cattle. The Lincoln Avenue stanchion barns have received a major face lift, a fully automated polygon parlor for milking has been built at the dairy automation area, the construction of a 200-unit confinement facility for heifers has been completed, and construction is underway on a new machinery storage building and shop.

Funding for these facilities has come largely through the Food for Century III Program, one that is providing new facilities and research opportunities for the College of Agriculture and the College of Veterinary Medicine. Major facilities, consolidations, and modernizations for the Department of Dairy Science have been proposed to College and University planners for the last 10 years. The modernization of the dairy facilities was funded during the first year of the Food for Century III Program. As the program progressed, federal funds from the Illinois Agricultural Experiment Station were used to supplement funds from the Food for Century III Program in order to complete the package of projects.

REMODELING OF THE LINCOLN AVENUE BARNS

Until last summer, the dairy barns on Lincoln Avenue had remained essentially unchanged since they were built in 1925. The cows are larger now, the stalls were rusted, and milking had been moved to a parlor. The buildings are structurally sound, so remodeling was much more cost-effective than replacement. Nagging problems created the need for remodeling, including stalls that were too narrow and short for today's cows, gutters that were too narrow and shallow to hold an overnight accumulation of manure during the winter, and feed mangers that were very awkward to use. The design of the old stanchions caused many cows to have skinned front legs. Ocassionally, a cow would break a leg when getting caught underneath a stanchion. Other considerations included the presence of many shear points in the gutter scraper system, a generally dirty and dingy appearance when visitors came, and an outdated and inadequate ventilation system that caused a number of pneumonia cases each year.

For the remodeling, the old stanchions and concrete were removed. New equipment was installed. The loft supports were relocated to allow for wider stalls. The ceiling was removed. Insulation was installed and then covered with Kemlite plastic bonded to plywood to provide a white ceiling that would be easy to clean. A new ventilation system was added, utilizing the air flow from the loft and a combination of constant- and variable-speed fans for controlled air movement. Rubber mats for the stalls were embedded in the wet concrete, making the mats part of the structure. Fluorescent lights were installed. The walls received a coat of white epoxy paint, after a thorough cleaning. The new feed mangers are flat and are lined with fiberglass for easy cleaning.

Stalls in the north barn were sized for 1,400-pound cows (5 feet 9 inches by 4 feet 6 inches). The south barn was changed so the stanchions face out instead of in. The south barn now has stalls for 1,400-pound cows (5 feet 9 inches by 4 feet 6 inches), 1,200-pound cows (5 feet 6 inches by 4 feet), and 1,000-pound cows (4 feet 10 inches by 3 feet 8 inches). The gutters are 18 inches wide and 16 inches deep. The shear points, which had been criticized by safety inspectors, were eliminated by using grates and covers for the gutters.

The southwest barn received a new ventilation system and ceiling, the same as the other barns. Space along the east side of the barn, long used to raise young calves, was remodeled to provide additional maternity space. There are enough box stalls now in the southwest barn to provide maternity space for the 275-cow herd.

CONFINEMENT HEIFER FACILITY

Another major change in our facilities was the construction of a new 200-head unit for replacement heifers. Previously, the heifers were housed at several locations. For the last 15 to 20 years, over 100 heifers had been kept at the McCullough farm on South Race Street; but that unit was isolated from the rest of our operation and was inefficient in terms of labor. Such problems limited the conduct of research with heifers. During the winter, it was almost impossible to keep the heifers clean. Open-type, portable shelters were constructed in the late 1960's and early 1970's, but these units had deteriorated and needed to be replaced. In addition, the heifer facilities in the round barn are now isolated from the main unit because of the veterinary clinics for large and small animals, buildings that were constructed during the mid-1970's.

Our new facilities for heifers consist of 2 housing sheds, one for large and one for small heifers. The building for small heifers has 6 bays of free stalls. The free stalls in that unit are of three sizes: 3 feet 10 inches by 2 feet 6 inches, 4 feet 10 inches by 2 feet 9 inches, and 5 feet 10 inches by 3 feet. The stalls are made for heifers, starting at about 3 months of age. The other housing shed contains 4 bays of free stalls (6 feet 4 inches by 3 feet 5 inches and 6 feet 10 inches by 3 feet 10 inches) for yearling heifers and includes rooms for veterinary care, breeding heifers, and weighing them. Each bay has an open lot to the east using fence-line bunks for feeding. In the winter and during wet weather, the heifers will be confined. In the summer, pasture plots will provide additional comfort and a place to exercise. For feed storage, we now have 2 silos (20 by 80) and 2 large grain bins. A storage shed (48 by 64 by 16) will hold 200 tons of hay. The manure will be scraped to a center pit and pumped by a chopper pump powered by electricity into a storage unit that is 61 feet in diameter. That unit will hold 410,000 gallons of liquid. The runoff from the feed lot will be handled through a system of pipes underneath the concrete lots, using the 12-inch PVC piping. The runoff empties into the manure pit. From there, the runoff can be routed into the slurrystone unit, if needed, or pumped out onto the pasture lots for irrigation.

THE POLYGON MILKING PARLOR

One of the interdisciplinary research programs in the department involves developmental engineering designs for ways of handling cows with less labor or by a more-efficient use of labor. The previous work has concerned automated feeding. The program has provided strong results concerning methods of group feeding and, recently, methods of feeding cows individually while they are housed in groups. About 3 years ago, the emphasis was shifted to automating the milking and the recordkeeping process in the parlor. One result is the new ploygon milking parlor, the first one in Illinois. As the planning for the parlor developed, it became apparent that the new facility should provide ways of achieving several objectives.

The first objective was to build a parlor that could house a computerized management system. On-farm computer systems are on the horizon, with automatic monitoring for milk yields and electronic identification of the cows. The application of engineering technology to bring these components together for a computerized dairy-management system was the primary justification for the new facility.

The second objective was to improve the facilities for milking management and for studies of mastitis. The expansion of the College of Veterinary Medicine has made the University dairy herd a primary teaching resource for Veterinary College students concerned with mastitis and milking management. The double-four milking parlor which has been used at the automation area since 1966 did not have room in the pit for an instructor and the students. The facilities needed for an expanded research program in udder health also called for more room in the milking parlor.

The third objective was to provide facilities for labor-management studies within the milking process. The development of detachers, large parlors, and new designs have brought about a revolution in milking techniques. A polygon parlor could incorporate the flow patterns for the cows and the design features that have been so popular in the Southwest while also allowing the study of contrasting milking practices and equipment for research purposes.

The fourth objective was to improve the labor efficiency on our research farms. Based on estimates for throughput in parlors of a similar size and design, it appears that 180 to 200 cows per hour could be milked in the new parlor with 2 people, including all required movement of the cows. One person would be the lead milker, washing and preparing the cows and attaching the milking units. That person would work around the whole parlor, instead of only on one side as in a herringbone parlor. The second person would help move the cows, dip the teats, and adjust the milking units when needed.

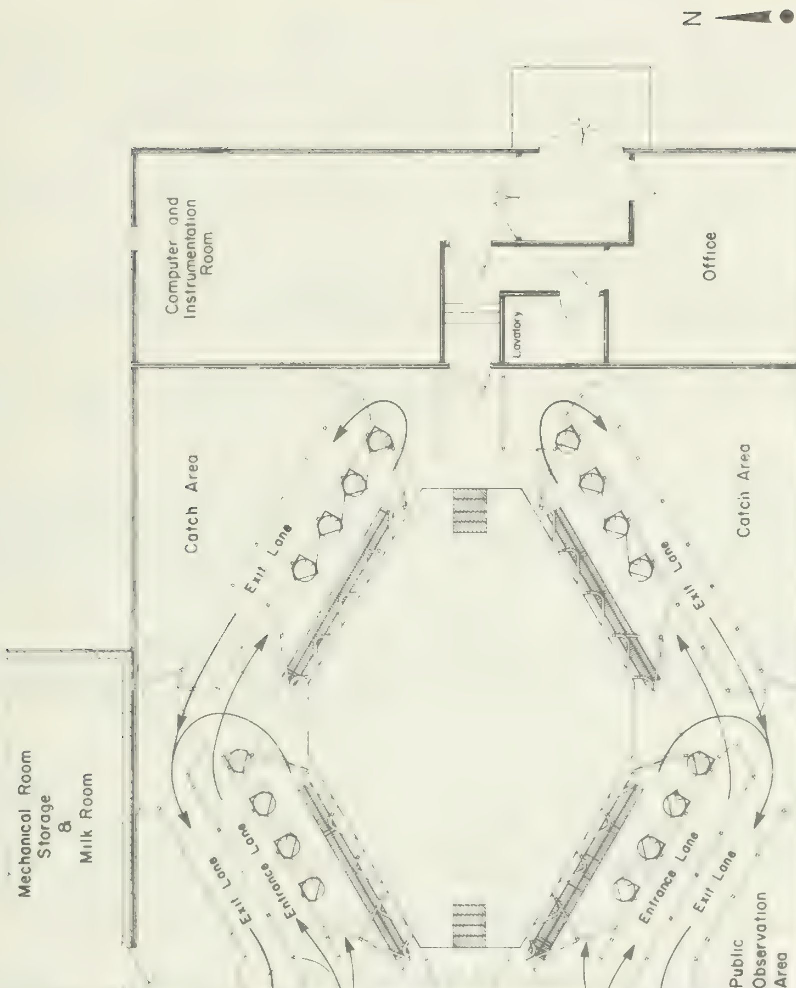
The research features of the new parlor include automatic detachers, electronic milk-flow meters, an on-site computer for automatically recording milk yields, and an automatic electronic identification system used as the cows enter the parlor. Two crowd gates are placed in the holding area so that one lot of approximately 40 cows can be milked on a side with the one crowd gate controlling their movement as another lot is being milked on the other side. The parlor will also have weigh jars, power gates, a claw unit that can be cleaned in place, and inside return alleys. Heat extracted from the milk will be recycled to heat hot water. Grain feeding will be done entirely in the lots. The udders will be washed and stimulated for milk letdown by hand.

THE MACHINERY STORAGE AND SHOP BUILDING

As part of the consolidation process, the headquarters for the farming operation that covers 400 acres of land farmed by the Department of Dairy Science will be moved from the round barn to the area on Lincoln Avenue. A new machinery storage area has been constructed. A heated shop area is planned for one end of the building. Sealed rooms will be constructed for the storage of seeds and chemicals. A welding area will be available for the first time, and the facilities will be greatly improved for maintaining and repairing the machinery.

NEW EQUIPMENT

Feeding cows housed in groups individually has been employed at the University for several years in one lot by using the transponder feeding system. In 1978, 4 new stalls capable of providing feed for 72 additional cows were installed, along with electronic monitoring equipment. The amount of time each stall is occupied and the amount of grain fed through each



University of Illinois
Dairy Research Parlor
4 x 4 Polygon

feed dispenser can be recorded automatically by the on-site computer system. In 1979, electronic identification was added to the system to provide a way of monitoring stall occupancy and the amount of feed dispensed to each cow.

A new feed-control panel with solid-state electronics and sequential programming of equipment startup was put in last summer. The unit can control the delivery of any mix of haylage, corn silage, and two concentrate mixes to the 5 lots with automatic controls for feeding.

A new waste-handling system has been installed to take care of manure from the free-stall housing units. An electrically powered chopper pump moves the manure from the pit to a 300,000 gallon slurrystone unit. Either fresh manure or manure stored in the slurrystone unit can be pumped into a solids-liquid separator. The separator uses the concept of perforated rollers to squeeze out the liquid and separate it from the fiber. The resulting washed fiber contains about 70 percent moisture and can be recycled as bedding.

A new 2,500-gallon tank with a heat-exchanger is used to heat hot water. In the winter, the heat from one air-cooled compressor is recirculated through the milk room to provide some heat.

Automatic detachers and milk-flow meters were installed in one parlor last winter. By installing detachers, we have accepted this labor-saving practice as a procedure that has been perfected to the point that we believe dairymen should no longer refrain from using it because of concerns about poor performance. The milk-flow meters are part of the department's research program and will be integrated into the on-site computer system.

The changes described here have been made with the idea of updating the University's technology and improving labor efficiency in our handling of dairy cattle. Several more changes are planned for the coming year in our never-ending quest to keep abreast of new technology.

Individual Feeding for Dairy Cattle Housed in Groups

SIDNEY L. SPAHR AND CHANDRA M. SHRESTHA

ELECTRONICS IS COMING OF AGE ON THE DAIRY FARM. The impact is seen in the milking parlor, with electronic scales on feed trailers, electronic tractor controls, and electronic controls for various small appliances in the farm home. One use of electronics in dairying is the development of the transponder feeder system. This system provides an answer to a nagging problem for many dairymen—how to achieve individuality in feeding when cows are housed in groups.

HOW IT WORKS

The central component of the electronic feeder is the transponder, a unit worn around the neck of the cow. The transponder is charged at a controlled rate when the cow steps up to the feed dispenser and places the transponder in an electronic field created by an interragator loop antenna located around the opening for the cow's head at the feed dispenser. As long as the transponder is being charged, a signal generator in the transponder sends out an electronic signal. That signal is picked up by the interragator loop antenna, causing a feed meter to dispense grain. The transponder stops charging when full charge is reached on an analog memory device, just like a battery. The signal generator then stops and so does the feed dispenser.

The unit discharges at a linear rate. So no more feed will be dispensed until a time lapse has occurred allowing the charge to at least partially leak off the transponder. The setting on each transponder controls the rate at which the transponder is charged. Thus, fast changes correspond to short feeding times and slow changes to long feeding times. The amount of feed dispensed per day for an individual cow is a function of the feed dispenser and the time set on the transponder.

Cows have access to the feeding stalls continuously, except when they are removed from the lot for milking. A cow can come into the stall as many times as she wishes each day. The

otal quantity of feed per unit of time will be the same. If she comes more often, she will imply receive a smaller amount per trip.

THE UNIVERSITY OF ILLINOIS SYSTEM

pneumatic feed-conveying system transports a grain mixture from a mix mill to a feed storge bin in the University of Illinois system. Feed dispensers are filled automatically by flexible auger in one setup, and by a chicken feeder-type drag chain in another. Thus, he system provides individual feeding for grain and does it automatically. The only addiional labor involved is to adjust the settings on the transponders approximately once a onth, or as indicated by changes in daily milk production.

his approach to individual feeding for cows housed in groups has been under study at the niversity of Illinois for approximately the last 10 years. We are now feeding 140 cows heir entire grain allotment in 4 different lots with this system. A main focus of our reearch studies has been to see how many cows each stall could handle—or, expressed another ay, how many pounds of grain could be dispensed per day through each stall while retaining ndividual feeding.

ome early studies indicated that the time cows would dawdle at the feeders was a problem. ater, as new ideas were tried, the "eating speed," or rate of grain consumption, was inreased by altering the shape of the feed bowl to correspond roughly to the shape of the ow's head, thus confining the grain to a small area. The turnover rate was found to be afected by the length of protective bars on the side. Some butting, or "social interaction," oes occur with the use of such feeders; however, the amount of such activity can also be ontrolled by the length of the bars along the side of the feeder. Short bars promote more utting and a faster turnover at the feeders; longer bars, more dawdling time.

he behavior of the cows is also associated with the rate at which the feeders are loaded. ith what we now consider relatively light loading rates (number of cows per stall or amount f grain programmed per stall), cows tended to occupy the stalls a relatively long time, even hen grain was not being dispensed. By increasing the loading rates, we found that the effiiency of stall usage was improved, with less dawdling time at the stalls.

STUDYING THE STALL LOADING RATE

ost of our studies where controlled information was possible have been conducted with a 2-nit feeder, utilizing a lot which could house 44 cows. The stalls could provide all the rain necessary for the 44 cows, even when the average production was more than 60 pounds of ilk per day. In 1978, we devised a trial to simulate loading rates that we thought would xceed the capacity of the system. An 8-week study was conducted with heavier loading rates eing simulated by making the feeders available 60, 50, 40, or 30 minutes during each hour, sing timers.

he results of this trial are outlined in Table 1. The amount of feed dispensed expressed s a percentage of the total amount of feed programmed was 98, 96, 92, and 78 percent, reectively, for the times listed, which represented simulated, programmed dispensing times f 475, 570, 712, and 950 minutes of feed time per stall per day. The number of times cows ntered the stall and received feed decreased, the number of different cows entering the same tall per hour went down, and the number of entries per cow per hour was approximately the ame with the heavier simulated stall loading rates as with the lighter rates. More grain as dispensed and the stalls were occupied more at night than during the day. This study onfirmed several earlier independent 24-hour cow watches concerning behavior of the cows.

he following conclusions were derived from this study and earlier ones. (1) Most cows keep heir transponders close to a full charge. Thus, most cows receive their grain in small eals throughout the 24-hour period. (2) The time per visit is usually low. (3) The turnver of cows per feeder is high. (4) The reduced feeding time created by the simulated, eavier loading rates (in this study) or from large numbers of cows per feed stall or high mounts of grain programmed per hour, or a combination of these factors, resulted in a reuction in the number of stall uses per cow and less feed being dispensed, expressed as a ercent of the feed programmed, compared to lighter loading rates. Heavy stall loading rates lso resulted in the stalls being occupied more of the time; also, when the stalls were occuied, more feed was being dispensed during that time.

Table 1. Effect of Variable Loading Rates on Stall Use[a]

	Stall operation time per hour (min.)			
	60	50	40	30
Daily operation, time per stall (min.)	1,440	1,200	960	720
Simulated daily programmed dispensing time per stall (min.)	463	556	694	926
Occupancy (min. per day per stall)	1,098	946	839	597
Dispensing time achieved (%)	98	96	92	78
Dispensing, % of occupancy	42	58	53	61
Entries (avg. no. per hr. per stall)	13.8	15.7	11.8	10.2
Entries (avg. no. per cow per day, 2 stalls)	26.0	28.0	20.8	19.1

[a]Two stalls, 44 cows. Initial daily milk, 58.4 pounds.

In our experience with heavy stall loading rates, the stalls were occupied as much as 80 percent of the time. The grain dispensing exceeded 60 percent of the occupancy time. With low loading rates, grain is dispensed only 40 to 50 percent of the occupancy time. With our management system, there seems to be no problem in achieving at least 650 minutes of feeding time per day per stall, while also having more than 95 percent of the programmed feed actually dispensed on an individual cow basis at 10 to 36 pounds per cow daily.

Progesterone Concentrations in Milk: A Reproductive Management Tool

SIDNEY L. SPAHR AND THOMAS R. DRENDEL

DOES TESTING MILK FOR ITS PROGESTERONE CONTENT have a place in the routine reproductive-management program for a dairy herd? It may for dairymen who have problems in detecting estrus and difficulties with long intervals after calving before the cows show signs of estrus; also, when pregnancy determination by some method other than the traditional rectal palpation is desired. Recent research at the University of Illinois has attempted to characterize the ways in which the test for progesterone in the milk can be used and what its limitations may be.

HOW THE TEST WORKS

Progesterone is a steriod hormone produced by the corpus luteum on the ovary. Progesterone is secreted into the blood and is transferred to the milk. At the time of estrus, the concentration of progesterone in the milk is low. Within 2 or 3 days after estrus, the corpus luteum begins its growth and the secretion of progesterone increases. The concentration of progesterone goes up rapidly for about 10 days, then remains high until shortly before the next estrus.

If the cow is not bred or has not conceived, the corpus luteum regresses 3 to 4 days before the next estrus and the concentration of progesterone in the milk drops quickly. But if the cow has conceived, the corpus luteum is maintained and the concentration of progesterone in the milk remains high.

This marked difference in the progesterone concentration in the milk of a pregnant cow at 2 to 24 days after breeding is the basis for the pregnancy test. If the pattern of progesterone concentrations needs to be established in order to know when the cow's estrus cycle begins and ends, multiple samples are taken 3 to 4 days apart.

UI RESEARCH RESULTS

Studies at the University of Illinois have been conducted in order to determine the source of variation in the concentrations of progesterone in the milk and the facts associated with the use of the test as well as its accuracy. In order to get the best results from using the test, the following factors need to be understood.

1. STAGE OF MILKING. Progesterone has a high affinity for fat. Therefore, the progesterone concentrations are low in foremilk, intermediate in bucket milk, and high in strippings.

A field trial was carried out with 18 dairy herds in Illinois, comparing bucket milk and strippings. Several of the herds had weigh jars or in-line samplers which made it possible to collect milk samples routinely from the bucket milk and from strippings.

The results, given in Table 1, show that the concentration of progesterone in the strippings was about 20 percent higher than in the bucket samples; however, the accuracy of the progesterone test for pregnancy did not vary with the sample sources. The reason for high accuracy with the strippings is that even with milk strippings, the concentration of progesterone is quite low at estrus.

Cows that are pregnant or ones in the luteal phase of their cycle usually have at least 6 times as much progesterone in their milk as those that are in estrus. The accuracy of the test is lower with foremilk because it varies more from one cow to another in terms of fat content and, thus, in the progesterone content.

STORAGE. Milk can be stored for several days if it is preserved. By using potassium dichromate preservatives and a refrigerator or freezer, several samples can be collected by the dairyman before sending them in for analysis.

SAMPLING DATE. Correct timing in obtaining the sample is essential. Milk progesterone is very low for about 3 to 5 days around the time of estrus. A milk sample with a high progesterone content simply means that the cow is not in estrus. Such a sample does not necessarily signify that the cow is pregnant, unless the sample is taken 21 to 24 days after her previous estrus. The fact that milk progesterone stays low for 3 to 5 days allows some flexibility in taking the sample for the test. For research purposes, most of our samples were taken at 21 days; however, to minimize the cost of pregnancy diagnosis, we would suggest waiting until 23 to 24 days after breeding. By so doing, the dairyman would not have to sample the cows that come into estrus on day 22 or 23. Data from our laboratory and experience in England indicate that no reduction in accuracy occurs up to about 24 days after breeding.

BREED. We wondered about the effect of breed, since different breeds of dairy cows have different percentages of fat in their milk and since progesterone has such a high affinity for fat. Even though the fat percentages were slightly higher with Jerseys and Guernseys (Table 1), we encountered no problems. The reason was that the usual difference in the concentration of progesterone in the milk for cows in estrus and for those that are pregnant or in the luteal phase of their cycle is at least 6 fold. Also, there is quite a lot of variation from one cow to another as well as for the same cow from one day to the next. So the breed differences are quite small and do not require a different cutoff point in taking samples for the progesterone test for pregnancy.

Table 1. Variations in the Progesterone Content of Cows' Milk

	Pregnant		Not pregnant	
	Bucket milk	Strippings	Bucket milk	Strippings
	nanograms per milliliter			
Holsteins	22.6(97)[a]	27.4(97)[a]	0.9(33)[a]	1.0(33)[a]
Guernseys & Jerseys	26.6(21)[a]	28.0(21)[a]	2.1(6)[a]	4.2(6)[a]

[a]Number of cows.

ACCURACY OF THE TEST

ıe test will identify the cows that are not pregnant, are cycling, or are near the time of ·trus with an accuracy of more than 95 percent. If the cow has been into estrus previously ıd has a very low concentration of progesterone in her milk, you can be almost certain that ıe is not pregnant and is near the time of estrus.

fact, there is no known physiological condition in which the cow would have a low concenation of progesterone and still be pregnant. Occasionally, though (about 2 percent of the ses in our experience), we have documented cases in which cows with a low concentration of ogesterone in the milk were pregnant.

The other situation under which cows would have a low concentration of progesterone and not be pregnant is very early after freshening, before starting to cycle. Multiple sampling is recommended when a dairyman is checking out cows in early lactation (less than 30 days) for estrus cycles and when the cows have shown no previous signs of estrus.

A high progesterone concentration 21 to 24 days after breeding indicates that the cow is likely to be pregnant. In our experience and in field trials carried out elsewhere, about 80 percent of the cows with high levels of progesterone 21 to 24 days after breeding will actually be carrying a calf at 60 to 90 days. There are four reasons why a pregnancy designation will not be more than 80 percent in agreement with fertility later.

1. EMBRYONIC MORTALITY. The cow may actually be pregnant at 21 days but the embryo may die at an early stage of development. This is the most important reason for the 20 percent variation in the accuracy of the test.

2. ERRORS IN ESTRUS DETECTION AT INSEMINATION. Obtaining a sample at the right stage of the estrus cycle is a must for high accuracy in using the progesterone test for pregnancy. If a mistake in estrus detection is made and a cow is bred when she is not actually in estrus, 21 days later she will not be in estrus and the level of progesterone in the milk will be high because of the natural cycle of hormone activity. This factor may be particularly troublesome with herds in which all cows are bred whenever they are thought to be in estrus and especially if poor methods of detection estrus are being used.

3. A FEW COWS WITH HABITUALLY LONG OR SHORT ESTRUS CYCLES. Since timing in relation to the estrus cycle is important, such cows may be diagnosed as pregnant inaccurately--the high concentration of progesterone being caused by the stage of the estrus cycle rather than by pregnancy.

4. PATHOLOGICALLY ALTERED ESTRUS CYCLES. Cows can have infections or metabolic disorders that would cause a hormone imbalance so that progesterone is secreted, but not as a result of pregnancy.

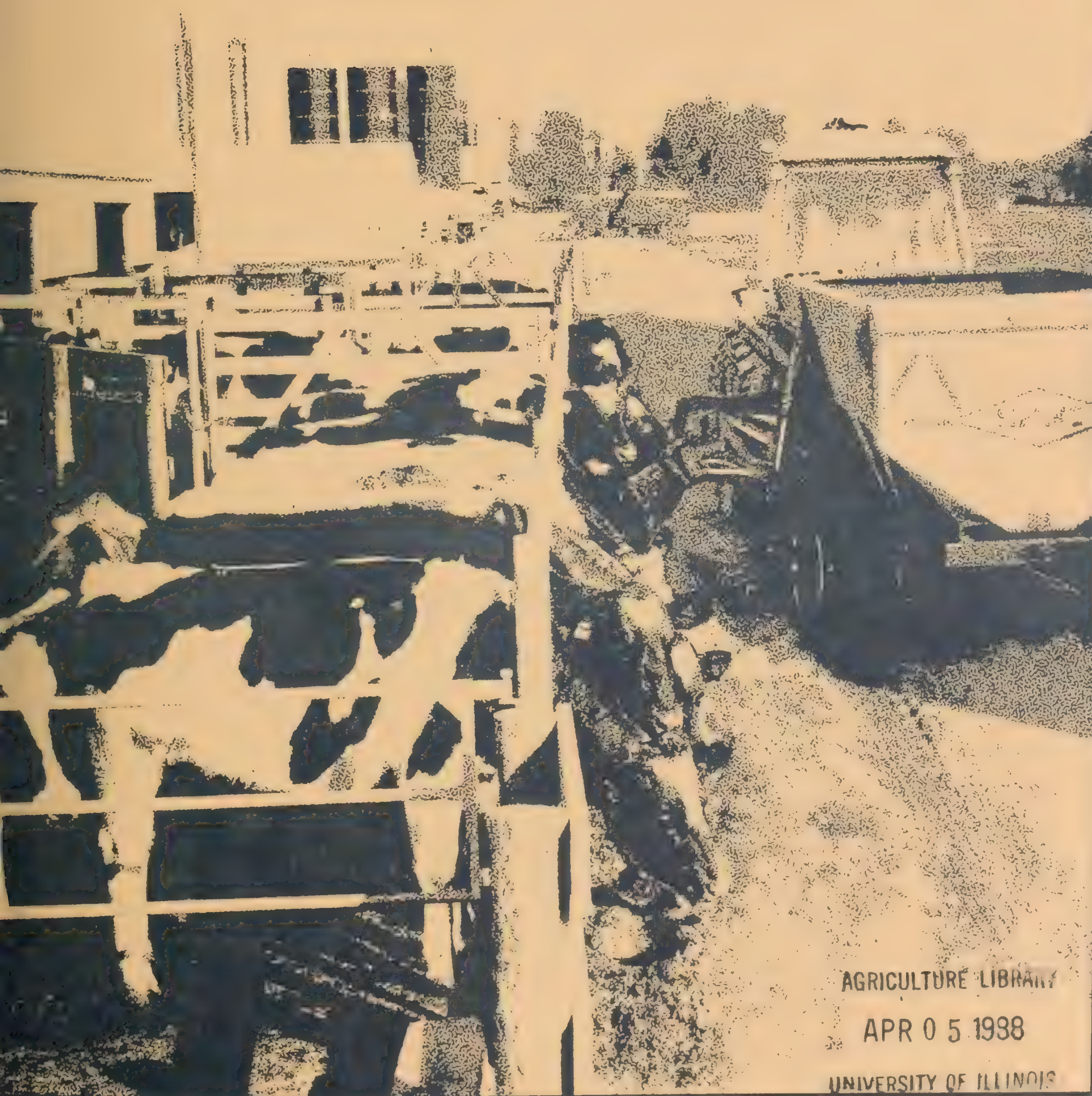
CONCLUSIONS

A progesterone assay of cows' milk can provide a convenient and effective method of determining whether or not cows are cycling, whether heat is being detected at the right time, and whether or not the cows are pregnant at 21 to 24 days after breeding. For the reasons given, the progesterone test is about 95 percent accurate in identifying cows that are not pregnant, are cycling, or are near the time of estrus and is about 80 percent accurate in identifying cows that are pregnant.

1981
Illinois Dairy Report

Department of Dairy Science
Cooperative Extension Service
Agricultural Experiment Station
College of Agriculture
University of Illinois at Urbana-Champaign

Feeding Strategies for the '80's



1981 Illinois Dairy Days

January 6 Sterling, Emerald Hill Country Club

7 Freeport, Holiday Inn

8 Marengo, Cloven Hoof Restaurant

9 Kankakee, Redwood Inn

January 13 Effingham, Extension Center

14 Breese, American Legion

15 Quincy, Ramada Inn

16 Peoria, Heritage House

Authors

Department of Dairy Science, University of Illinois at Urbana-Champaign, except as noted

MARVIN P. BRYANT, professor, ruminant microbiology

JIMMY H. CLARK, professor, dairy cattle nutrition

CARL L. DAVIS, professor, ruminant nutrition

CHARLES N. GRAVES, associate professor, reproductive physiology

DOUGLAS A. GRENAWALT, research assistant, nutrition

MICHAEL GROSSMAN, associate professor, genetics

RIC R. GRUMMER, research fellow, nutrition

ROBERT B. HESPELL, associate professor, microbiology

MICHAEL F. HUTJENS, professor and extension dairyman

EDWARD H. JASTER, assistant professor, management

BRUCE L. LARSON, professor, biochemistry and lactation and Acting Head of the Department

J. ROBERT LODGE, professor, reproductive physiology

GENE C. McCOY, associate dairy scientist, management

KATHLEEN A. ROONEY, research assistant, genetics

ROGER D. SHANKS, assistant professor, genetics

SIDNEY L. SPAHR, associate professor, management

G.R. WIGGANS, research geneticist, Agricultural Research Center, Beltsville, Maryland

Contents

The Department of Dairy Science

BRUCE L. LARSON

THIS 1981 DAIRY REPORT is the second in a series of annual reports from the Department of Dairy Science. This year's report contains information about the 1981 Dairy Day Program and discussions of various research projects taking place in the department. We are pleased to present it to you as one of our statewide educational programs and publications.

The Department of Dairy Science, University of Illinois at Urbana-Champaign exists to help the Illinois dairy industry with a diversified program of teaching, research, and public service through its Extension Service activities. The teaching program of the department provides a wide variety of educational opportunities ranging from four-year undergraduate programs to highly specialized graduate training programs leading to advanced degrees. We hope that members of your family will consider taking advantage of these or other educational opportunities available at the University of Illinois.

Many changes have been taking place at the Dairy Research Farm over the past few years, most of them being completed during the past year. The changes include an extensive remodeling of existing facilities and the construction of a new heifer-raising unit, feeding facilities, and a polygon milking parlor. The feeding and milking systems are highly automated. Computers control and record data for individual cows. An open house is planned for July 9, 1981. We invite you to inspect these new facilities then.

As 1981 begins, we are looking forward to the arrival of the new Head of the Department of Dairy Science, Dr. W. Reginald Gomes. He will be coming to the University of Illinois from Ohio State University and will assume his duties in Illinois on February 1. Dr. Gomes will replace Dr. Kenneth E. Harshbarger who left in August of 1979 for an assignment in Indonesia.

The list below shows the faculty members in the department. We also have an Advisory Committee composed of the following industry members: William Lenschow, Sycamore; Kevin Lyons, Granville; William McFadden, Apple River; Gordon Ropp, Normal; and Dale Schaufelberger, Greenville.

The faculty and the members of the committee invite your comments and suggestions. We appreciate your interest in the 1981 Dairy Day Program and hope it will be beneficial for you.

DEPARTMENT OF DAIRY SCIENCE

Full-time faculty members	Specialization
Craig R. Baumrucker, assistant professor . .	Lactation
Marvin P. Bryant, professor.	Ruminant microbiology
Jimmy H. Clark, professor.	Dairy cattle nutrition
Carl L. Davis, professor	Dairy cattle nutrition
W. Reginald Gomes, professor and Head of the Department (effective 2/1/81).	Reproductive physiology
Charles N. Graves, associate professor . . .	Reproductive physiology
Michael Grossman, associate professor. . . .	Dairy cattle genetics
Gerhard W. Harpestad, associate professor. .	Extension dairyman
Robert B. Hespell, associate professor . . .	Ruminant microbiology
Michael F. Hutjens, professor.	Extension dairyman
Edwin H. Jaster, assistant professor	Dairy cattle management
Ralph V. Johnson, associate professor. . . .	Extension dairyman
Bruce L. Larson, professor and Acting Head of the Department (until 2/1/81)	Biochemistry and lactation
J. Robert Lodge, professor	Reproductive physiology
Michael R. Murphy, assistant professor . . .	Dairy cattle nutrition
James L. Robinson, associate professor . . .	Biochemistry
Roger D. Shanks, assistant professor	Dairy cattle genetics
Sidney L. Spahr, associate professor	Dairy cattle management

Feeding Systems Spell Success

MICHAEL F. HUTJENS

AS ILLINOIS DAIRY FARMS CONTINUE TO GROW, more attention will be given to how component systems fit together and complement each other. The size of the average Illinois herd in 1979 was 33.2 cows, up from 27 in 1974. The shift is toward larger and larger herds (Table 1). As herd sizes increase, feeding systems and programs will need to keep pace in order to support optimum milk production.

Table 1. Patterns in Herd Sizes and Changes, Illinois, 1978 to 1979

No. of	Farms		Cow inventory	
cows	Percent	Change	Percent	Change
1 to 29	48	-4.0	8	-1.5
30 to 49	23	-1.4	26	-4.1
50 to 99	23	+2.2	45	+1.3
Over 100	5	+1.5	20	+3.7

A successful dairy feeding system can be defined as the ability to deliver needed nutrients to each cow at the correct time (stage of lactation) in order to maintain maximum milk production. Various challenges and problems with feeding systems are illustrated in Figure 1.

Three general feeding systems (forages, grain, and minerals) and total mix rations will be discussed. Each manager will have to select components to develop a successful feeding system in a particular operation.

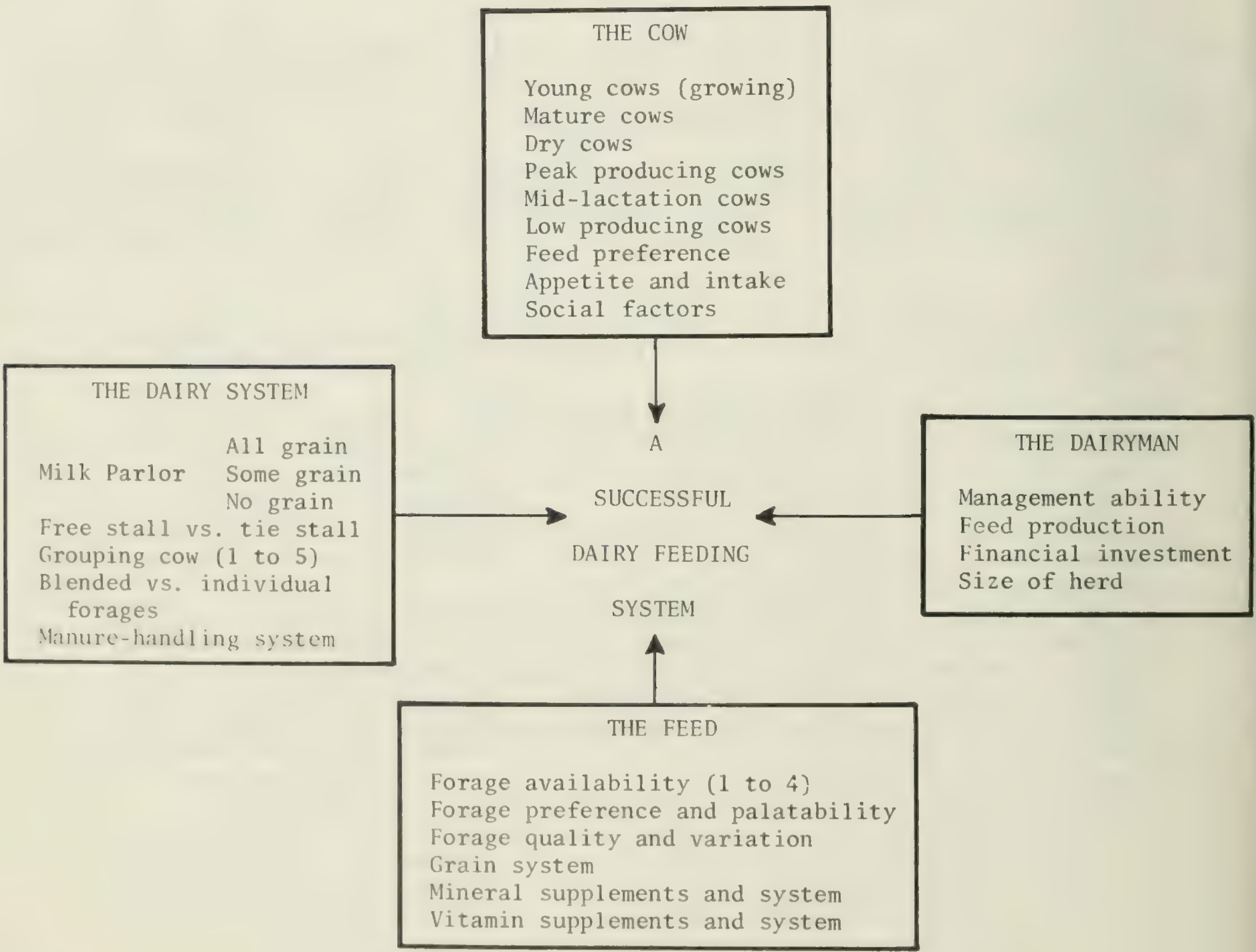


Figure 1. Factors that affect feeding systems on the dairy farm.

Forages are feeds relatively high in fiber and low in digestible nutrients including whole plant of corn, small grains (like oats or wheat), legumes, and grasses. Forages maintain digestion and function in the rumen, stimulate rumen microbial growth to support milk production, cause rumination and saliva production, and serve as an economical source of nutrients.

Forage selection depends largely on agronomic considerations (yields and the costs of nutrients produced per acre). Forage quality must be the primary consideration, regardless of forage type. Here are nutritional considerations for high-producing cows:

- Legume proteins are lower in rumen degradation than corn silage and grasses.
- Legumes have a greater buffering capacity in the pH range of 4 to 6 compared to grasses.
- Energy values for forages depend on the stage of maturity at harvest. Small grains should be harvested in the boot stage. The harvest of legume-grass forage should be completed when the last field is in the 1/4 to 1/2 bloom stage.

The minimum level of forage should be 1.35 percent of the body weight (1.5 percent if all forages are wet and ensiled). Another measure is that the dry matter in the ration should contain a minimum of 15 percent crude fiber.

HAY VERSUS HAYLAGE

Most dairy producers and researchers agree that high-quality hay makes an excellent forage. However, two limitations must be considered (Figure 2). Harvest losses and potential rain damage (with an extra drying day) are built-in factors associated with hay. Haylage minimizes the losses of dry matter and the weather risks.

Adding propionic acid-based preservatives to baled hay can lower field losses (baled wetter) and prevent mold formation. The level of acid needed will depend on the moisture level of the baled hay (at 20 to 25 percent moisture, add 0.5 percent propionic acid; at 25 to 30 percent, add 1 percent; and at over 30 percent, add 2 percent). Check the cost per bale compared to the improved hay quality and lower field losses. Be sure your preservative contains propionic acid or a comparable preservative agent.

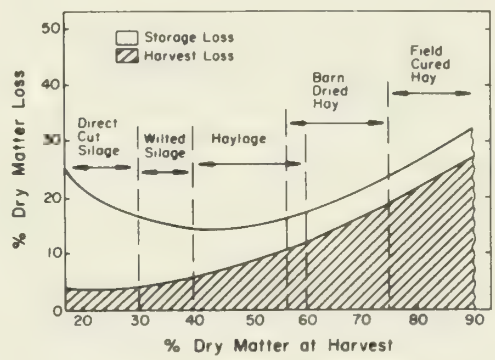


Figure 2. Estimated total harvest and storage losses when legume-grass forages are harvested at varying moisture levels and by different methods.

Storage systems for silage will depend on inventory needs and availability, continuous feed features, refill and double usage pattern, and the feed system (Table 2.)

Table 2. Stored Feed: Annual Costs per Ton

Type of silo	Size (feet)	Capacity (tons, DM)	Annual cost per ton[a] Dry matter	30% dry matter	50% dry matter
Oxygen-limiting	25 by 84	324	$29.94	$8.99[b]	$14.95[b]
				$5.99[c]	$ 9.98[c]
Concrete-stave	30 by 60	324	$14.90	$4.47	$ 7.45
Horizontal	12 by 40 by 112	300	$12.77	$3.83	$ 6.39

[a]Includes depreciation, interest, repairs, insurance, and operating costs based on tons put in storage (does not include field or storage losses).
[b]Filled once a year.
[c]Filled 1.5 times per year.

Source: 1979 Minnesota Silage Clinic Booklet.

Generally, horizontal silos become economical and practical when silage storage needs exceed 1,000 tons annually (333 tons of forage dry matter).

A comparison of hay-crop storage systems is given in Table 3. The effects of various losses, labor, and costs to provide 250 tons of hay-equivalent is compared with a yield of 4 tons per acre. Silo-press plastic storage in a 70-ton silage bag (35 percent dry matter) at a cost of $168 per bag is also illustrated. *Silage systems economize on land use.*

Table 3. Forage Storage: Costs of Alternate Systems (250 Tons Hay Equivalent Fed)

	Hay silage 30 percent dry matter			Haylage 50 percent dry matter		Hay 90 percent dry matter	
	Tower	Bunker	Plastic	Plastic	Oxygen-free	Large	Small
Harvest loss (percent)	5	5	5	10	10	23	23
Storage loss (percent)	10	14	10	8	8	11	4
Feeding loss (percent)	6	11	11	8	5	15	5
Acres of production needed[a]	77	86	82	82	79	107	91
Forage stored (tons)	886	979	936	531	515	330	280
Investment per ton of hay equivalent fed							
Storage	$ 88	$ 60	$ 16	$ 13	$144	$ 0	$ 40
Harvesting & feeding	140	116	176	176	144	109	97
Labor hours per ton of hay equivalent fed	.7	.7	.8	.7	.6	.5	.6
Ownership & operating costs per ton of hay equivalent fed	$ 36	$ 31	$ 40	$ 38	$ 42	$ 22	$ 34
Land & production cost per ton hay equivalent fed	43	49	46	46	44	58	50
Total cost per ton of hay equivalent fed	79	80	86	84	86	80	84

[a]Assumes a potential yield of 4 tons before harvest losses.
Prepared by R.A. Hinton, Extension Specialist, Farm Management, Department of Agricultural Economics, University of Illinois at Urbana-Champaign.

Two related aspects of the forage systems are feed availability (inventory control) and how much feed will be needed. Ideally, all feeds should be available for blending or for feeding directly as desired or needed. Common problems with inventory control are to have first-crop hay buried under second-crop hay, second-crop haylage between that from the first and third crop, and no haylage available until the corn silage is fed off the top. As a result, top-quality forage is fed to all of the cattle or poor-quality forage must be fed to the high producers in the herd. The solution may be to have 3 smaller silos, rather than 1 or 2 larger units. This also allows for a gradual shifting of feeds in the ration, rather than abrupt changes. Plan your feeding strategies according to the forage you have (Table 4).

Table 4. Yearly Forage Requirements of a Lactating Cow[a]

	Forage fed pounds per day				
Corn silage	60	45	30	15	0
Alfalfa hay[b]	..	5	12	18	23
Milk (3.5% fat)	tons per year[c]				
18,000 pounds					
Corn silage	12.6	9.8	6.1	3.1	...
Alfalfa hay[b]	...	1.1	2.5	3.6	4.8
	(See forage fed, at left)				
15,000 pounds					
Corn silage	12.9	10.1	6.2	3.2	...
Alfalfa hay[b]	...	1.1	2.6	3.8	5.1
13,000 pounds					
Corn silage	13.6	10.6	6.7	3.3	...
Alfalfa hay[b]	...	1.2	2.7	4.0	5.3

[a]Based on a 1,500 pounds per cow. Reduce amounts 10 to 20 percent for smaller cows. [b]Multiply by 2 if haylage is used. [c]From silage at 35 percent dry matter and alfalfa hay at 86 percent dry matter. Includes dry period and 15 percent storage and feeding loss.

As milk production increases, more grain is substituted for forage resulting in a greater intake of dry matter (Figure 3) and the potential for higher milk production (Table 5).

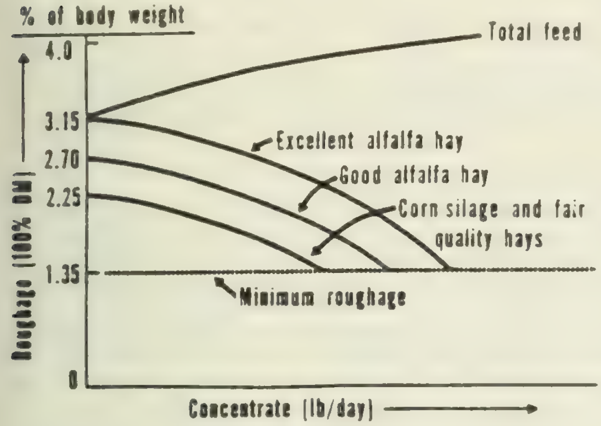


Figure 3. Substituting grain for forage.

Table 5. Pounds of Potential Milk, Based on Energy

Forage	Diet 100	(forage-grain ratio) 80:20	60:40	40:60
	pounds of milk			
Alfalfa, prebloom	43	52	61	72
Alfalfa, mature	14	26	41	57
Corn silage	41	52	63	72

However, a point of maximum energy concentration does occur. Higher energy levels result in lower total digestibility, reduced feed intake, or lowered fat tests. This point occurs when over 60 percent of the dry matter in the ration is grain, over 30 pounds of dry matter in the grain is fed per cow per day, or the energy level in dry matter exceeds 75 percent TDN or 0.78 megacalories of net energy. In most cases, dairy producers know how much grain each cow needs, but fulfilling that need is another matter.

GRAIN IN THE MILKING PARLOR

Milking cows in parlors is an increasingly popular practice, and various levels of grain can be fed there. Be alert, however, to the rate at which grain is consumed and the time spent in the parlor (Table 6). The main advantage of feeding grain in the parlor is that the cows can be moved in the parlor in less time. The disadvantages include dustiness, more defecation, cows that linger on the way out, the expense of installing and replacing feed equipment, and the tendency for all cows to receive the same amount of grain.

Table 6. Typical Rates, Grain Consumption

Type of grain	Pounds per minute
Pelleted	1 to 1.2
Coarsely ground or cracked	.75
Average to finely ground	.50

ALTERNATE SYSTEMS FOR GRAIN FEEDING

Dairy producers have problems getting high-producing cows to eat adequate amounts of grain in the parlor. Totally mixed rations may not be feasible because of herd size, existing facilities, and forage programs. So types of mechanized grain-feeding systems need to be considered.

1. FREE-CHOICE, ELECTRONIC GRAIN FEEDERS. In such systems, the cows carry identification units (a magnet, key, or chain) that control their access to or turn at the feeding station. Unlimited feed is available on a free-choice basis. Examples of this type of unit are the Calan Feeding Door and the Northco Servo-O-Matic. The cost is about $700 for units that can handle 20 to 25 cows. Careful management is required. Excessive feed intake must be avoided, and the identification device must be removed when production drops. The advantages of this system include a low initial investment and a simple design. The major disadvantage is that having access to feed free-choice can result in digestive problems and marginal economic returns from the additional grain fed.
2. PRESET OR LIMITED ELECTRONIC GRAIN FEEDERS. The technology is rapidly changing and improving in these systems. The dairy producer or a computer controls the amount of grain to be fed to selected cows. The system cost varies from $5,000 to $20,000 for 30 to 50 cows depending on the complexity of the system purchased:
   a. Electronic cow identification tied to a predetermined level of grain which is set by the manager or programmed by a computer.

b. Central computer unit with or without a printer to list daily grain intakes and cows that do not consume desired grain levels.

c. Computer determined and adjusted grain levels based on milk production.

d. Controlled proportioning of the grain allocation.

e. A warning system if feed blockage, component problem, or power interruption occurs.

Examples of these preset systems for grain feeding include the DeLaval Ration Master and Challenger, Horn of Plenty Automatic Herdsman, and TESA Computer Controlled Outside Concentrate Feeder.

Regardless of which feeder system is selected, the management provided by the dairy producer must be topnotch. The nutrient specifications in the feeder should be based on the forage program, level of milk production, and other grain sources used. Adding a buffer and the use of an all-natural, low-degraded protein feed source as well as a digestible fiber source should be considered. Part or all of the grain can be delivered through the feeder, but the pressure by the cows on the system and the total grain-dispensing level should not exceed the unit's capability. Be aware of problems with boss cows; also, such matters as stall length, protection of the unit, and the location of the feeding stations in relation to the traffic pattern by the cows. Mississippi research has shown that with the use of adjusted grain feeders, milk production comparable to that with a total mixed ration (TMR), can be maintained (Table 7).

Table 7. Comparison of Grain Feeders and a TMR System

	Calan	DeLaval	Tesa	TMR
Milk (pounds per cow per day)	47.3	49.9	47.5	49.5
Milk fat test (percent)	4.38	4.37	4.52	4.39
Total intake of dry matter (pounds per cow per day)	40.9	42.5	40.9	46.0
Feed cost (per 100 pounds of milk)	$5.09	$5.02	$5.00	$5.65

THE TOTAL MIX RATION (TMR) SYSTEM

Total mixed rations, or complete rations, are defined as those with all of the forage and grain ingredients blended together, formulated to specific nutrient concentration, and fed free-choice. This TMR feeding system is *the* system of the future. The advantages of a TMR system include:

1. No choice of individual feeds.
2. A greater potential for dry-matter intake.
3. Specific feed formulation.
4. Weighing of ingredients.
5. Fewer digestive upsets.
6. Use of unpalatable feeds.
7. No grain dust and calmer cows in the parlor.
8. The potential for less labor.
9. Free-choice minerals not needed.

There are some potential disadvantages, too:

1. Long hay is difficult to handle or use.
2. Specialized equipment is needed.
3. Grouping is required.
4. Larger herd sizes are needed to justify the labor and equipment investment.
5. Cow movement patterns must be considered.
6. Rations must be carefully formulated and continually checked.

Group feeding by production strings is a critical factor in TMR systems. Here are guidelines about grouping:

1. The minimum requirement is 2 production groups plus a dry group. More strings are desirable in larger herds. A group of first-calf heifers has advantages, considering their size, competitiveness, and growth requirements.
2. After the fresh cows recover from calving (3 to 7 days if feasible), put all of them in the high group to challenge nutritionally for 2 months. Move certain cows to a lower group if their milk output does not warrant keeping them in the high-production group.
3. If nutrient specifications are adequate when the cows are moved between groups, their milk production should not drop.
4. Several options are available when cows are moved.
   - Move small groups of cows, rather than individuals.
   - Move cows on a regular schedule.
   - Regulate the string size, based on the size of the milking parlor or the feeding capacity (30 inches of manger space per cow).
   - Move cows during feeding times to minimize cow interactions.
   - Consider their reproduction status when moving cows. (Limit heat detection to one group or use a cleanup bull in a lower production group.)
5. Feed each string based on that string's higher producers (ration specification).

Smaller mixing units are available commercially for herds of 40 to 60 cows. Several feed carts on the market will work for mixing and weighing ingredients for feeding to herds using tie stalls or stanchions. The cost of this mixing equipment varies from $5,000 to $12,000 (carts to mobile-truck units), depending on the size, mobility, mechanization, and weighing device involved. There must be a weighing device on the mixer. Two types of weighing devices are available. Weigh bars are accurate within 1 percent and are not affected by slope. Load-cell mounts are more accurate (1/10 to 1/4 of 1 percent) and measure vertical loads. Either type of weighing device is acceptable.

MINERAL SYSTEMS

Minerals represent another group of nutrients cows require in specific amounts and proportions (Table 8). Both the cow and rumen microbes have mineral needs that must be met.

Table 8. Nutrient Content of Minerals for Lactating Dairy Cows (Maximum Production)

	Macro minerals (%)			Micro minerals (ppm)[b]	
	Minimum	Maximum		Minimum	Maximum
Calcium[a]	.60	...	Iron	50	1,000
Phosphorus[a]	.40	...	Cobalt	.1	10
Magnesium	.20	...	Copper	10	80
Potassium	.80	...	Manganese	40	1,000
Sodium	.18	...	Zinc	40	500
Sodium chloride	.46	5.0	Iodine	.5	50
Sulfur	.20	.35	Molybdenum	..	6
			Fluorine	..	30
			Selenium	.1	5

[a]The amount needed is related to milk production. [b]1 percent = 10,000 ppm.

Basically, two mineral systems are available for dairy producers.

1. FORCE FEEDING SYSTEMS, which include minerals mixed with the grain and forages, in a total mixed ration, or top-dressed.
2. FREE-CHOICE SYSTEMS, which include cafeteria style.

Forced feeding the minerals should be the system of choice. Cornell University researchers reported that cows fed rations deficient in calcium and phosphorus did not consume enough minerals free-choice to meet their requirements. In one study, only 60 percent of the cows consumed free-choice minerals. South Dakota results would not support the premise that lactating cows have the ability to select and consume minerals based on their needs or requirements. Minnesota field studies measured "luxury consumption" (the intake of minerals above requirements, free-choice). The average was nearly 1/4 pound per cow per day for 19 months at a cost of 3.4 cents per cow with no improvement in milk production or herd health.

A forced-feeding system should provide a daily intake of minerals to complement the forages and grains in the ration. The consumption of calcium and phosphorus should be increased as milk production goes up. Thus, the logical system choices are top-dressing, mixing with grain, or a total mixed ration. Consider the cost (per gram or pound) of purchased mineral, ration requirements, and mineral balance in setting up your system and selecting your mineral supplements.

Managing the Rumen

C.L. DAVIS AND J.H. CLARK

AS RECENTLY AS 30 YEARS AGO, the rumen was viewed as a "black box" with little or no significance to the animal, except as a storage vat for feed and water. During the intervening years our understanding of the rumen and the role it plays in the general nutrition and well being of the cow have changed drastically.

Today, we know that managing the rumen is of primary importance if the cow is to obtain maximum benefit from the nutrients in the diet and if the incidence of metabolic disorders and diseases states is to be reduced or prevented. Bloat, rumen parakeratosis, liver absesses, acidosis, low milk-fat production, and pulmonary emphysema are a few of the disorders linked directly to what goes on in the rumen.

As an open system, the rumen allows all microorganisms in the environment to enter. However, only the organisms that can live and reproduce under the nutritional and physiochemical constraints of the rumen environment will remain there.

Man probably cannot alter the microbial population in the rumen by adding a "super bug." If such an organism could live there, it probably would already be there. What we can do is to alter the microbial population normally existing in the rumen or their metabolism, which ultimately affects the nutrition of the animal.

The microbial population in the rumen consists of a large and diverse group of bacteria (1-cell plants) and protozoa (1-cell animals). Scientists differ in their views about the role of protozoa in the general well-being of the animal, but the importance of bacteria can be documented in many nutritional areas. A few of these are: (1) the synthesis of protein from nonprotein nitrogen; (2) the breakdown of cellulose and hemicellulose (fiber) into volatile fatty acids which the animal uses in its metabolism; (3) the synthesis of B vitamins; and (4) the detoxification of compounds that otherwise might be harmful to the animal.

The goal of the ruminant nutritionist is to manage the rumen in such a way that the needs of the microorganisms are met, taking full advantage of their ability to breakdown fiberous materials and to synthesize protein from nonprotein nitrogen. In addition, dietary components such as starch and high-quality protein would be shunted to the lower gut, thereby escaping breakdown in the rumen. In the lower gut, the animal's own digestive system handles them in a manner that conserves more of their nutritive value.

In recent years, research has brought to light the importance of the pH in the rumen fluid and the rate at which fluid flows out of the rumen on the breakdown of feedstuffs by the microorganisms (rate and extent), changes in the metabolic products formed, and the rate at which the bacteria grow. Considerable research effort has been directed toward altering

the rumen environment and, hence, the microbial population and its metabolism in order to determine the effects of these changes on nutrient availability and the animal's performance.

Today, we know that drastic changes in the composition of the diet, the amount fed, and the physical form can have a profound effect on microbial activity in the rumen and, therefore, on the nutrition of the animal. Microbial changes in the rumen are affected by alterations in the pH of the rumen contents, nutrient protection, rate at which dry matter is removed from the rumen, and water flow through the rumen.

EFFECTS OF RUMEN FLUID pH ON MICROBIAL FERMENTATION

To express the acidity or alkalinity of fluids, we use the pH scale.[1] The pH of fluids in the body is recognized as one of the most critical physical conditions affecting the animal. The rumen microorganisms are highly sensitive to changes in pH. Most prefer a pH of 6.5 to 6.8. In general, the growth rates and metabolic activities of microorganisms in the rumen are diminished as the pH falls below 6.5. This especially is true of those organisms that breakdown cellulose (fiber), as is shown in Figure 1.

The fiber-digesting bacteria are much more sensitive to high levels of acidity than are the starch-utilizing bacteria. In the rumen of cows fed a high-energy diet (one with more than 60 percent concentrate), pH values below 6.0 are common. Under such conditions, the number and activity of the fiber-digesting bacteria would be reduced greatly (Figure 2). Note the marked reduction in the breakdown of cotton fiber (cellulose) as the pH is reduced from 6.7 to 6.0.

Several factors contribute to changes in the pH of fluids in the rumen. The following are the most important ones.

1. TYPE OF DIET, especially roughages versus concentrates (Figure 3). Roughages stimulate a much higher rate of saliva secretion than do concentrates. Furthermore, the carbohydrates in roughages (cellulose and hemicellulose) are not broken down as rapidly by the rumen microorganisms as are the carbohydrates in the concentrates (starches and sugars).

2. PHYSICAL OR CHEMICAL NATURE OF THE DIET. Reducing the size of feedstuffs in the diet by chopping, grinding, and pelleting results in a drop in rumen pH, caused by a reduction in saliva secretion (Figure 4). Altering the nature of starch by a heat treatment (such as cooking or flaking) renders the starch more assessible to microbes for acid production, thus reducing the pH of the fluids within the rumen.

3. LEVEL OF FEED INTAKE (FIGURE 3). As the level increases, a reduction in the rumen pH is brought about by at least two factors: (a) more substrate is available for the microorganisms to use for converting feed into acids; and (b) as the level of feed intake increases, the rate of saliva secretion decreases per unit of feed consumed.

4. ADDING BUFFERS (BICARBONATES) TO THE DIET. This will adjust the pH upward, particularly with high-concentrate diets (Figure 5). Dairy cows in early lactation were fed a high-energy diet (40 percent corn silage and 60 percent concentrate, dry matter basis). The effects were measured of sodium bicarbonate (1.5 percent of the diet), magnesium oxide (0.8 percent of the diet), or both on the performance of the cows. The diet without buffers resulted in a marked depression in pH after feeding. A return to the prefeeding level required 10 to 12 hours. When both buffers were included in the diet, the rumen pH remained much higher and showed less fluctuation.

As the pH decreases below 6.2, there is a marked increase in the proportion of propionic acid produced in the rumen. A negative relationship exists between the proportion of rumen propionate and the fat content of the milk produced (Figure 6). Adjusting the pH from below 6.0 upward by adding buffers corrects the depression in tests for milk fat.

---

[1]The lower the reading, the higher the acidity and vice versa.

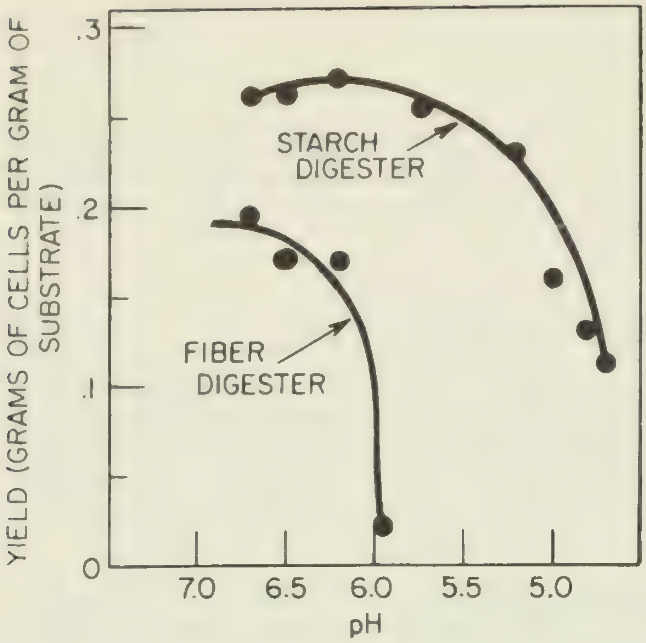


*Figure 1. Effect of pH on the growth yield of fiber degrading (*Ruminococcus albus*) and starch degrading (*Streptococcus bovis*) bacteria. [Russell and Dombrowski, Appl. and Environ. Microbial. 39:604].*

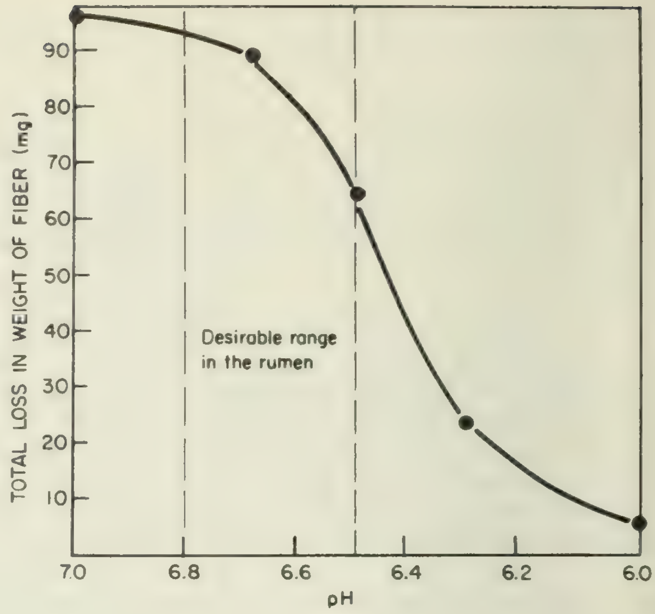


Figure 2. Effect of pH on the breakdown of fibers by microorganisms in the rumen.

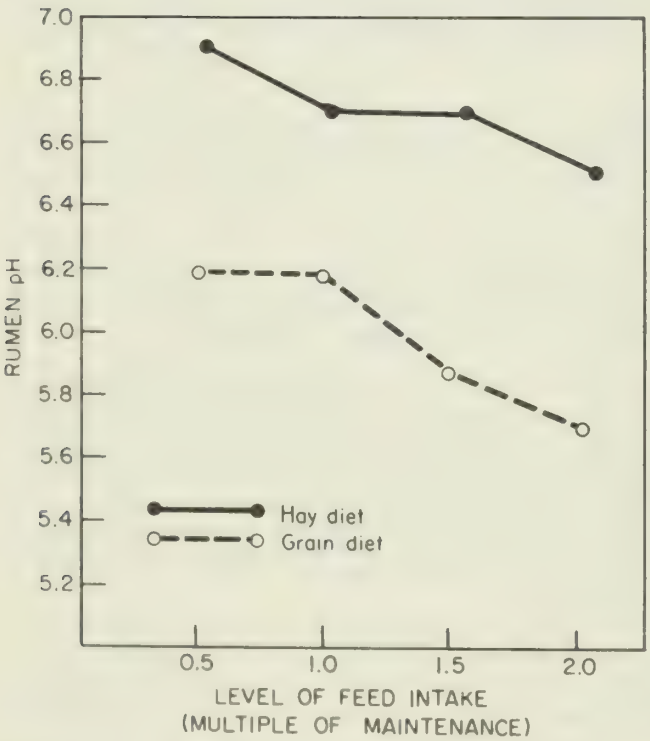


Figure 3. Effect of type of diet and level of feed intake on Rumen pH (Rumsey et al., J. Ami. Sci., 31:608).

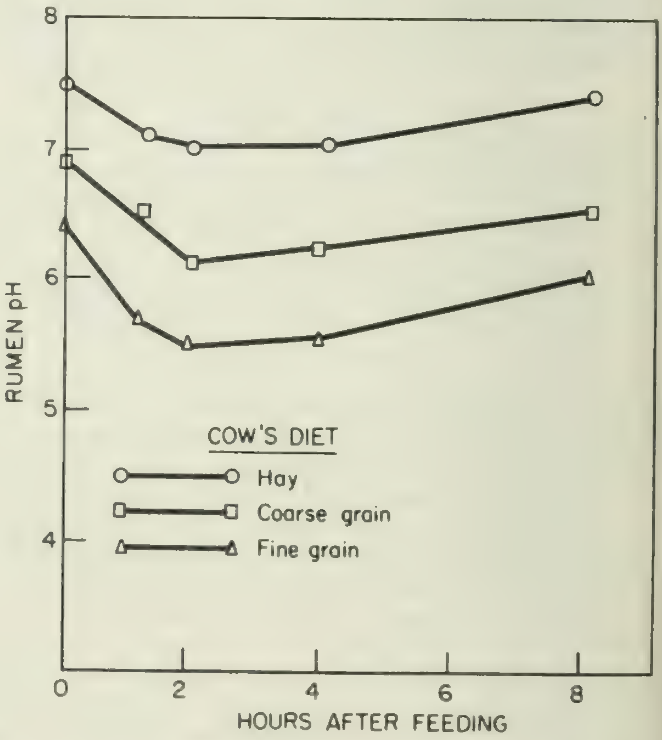


Figure 4. Pattern of pH reading's for fluid in the rumen, as affected by diet (adapted from Cheng and Hiromaka, Can. J. Ami. Sci., 53:417).

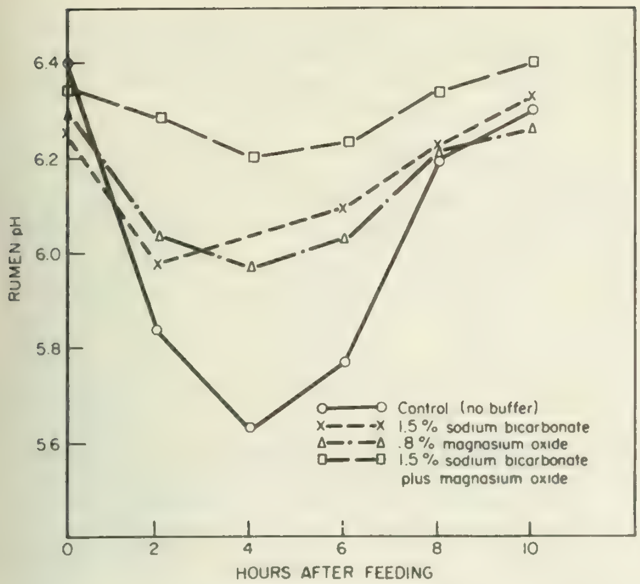


Figure 5. *Effects of buffers on rumen pH, lactating dairy cows on a diet of 40-percent corn silage and 60-percent grain, dry-matter basis (data supplied by Dr. Larry Muller).*

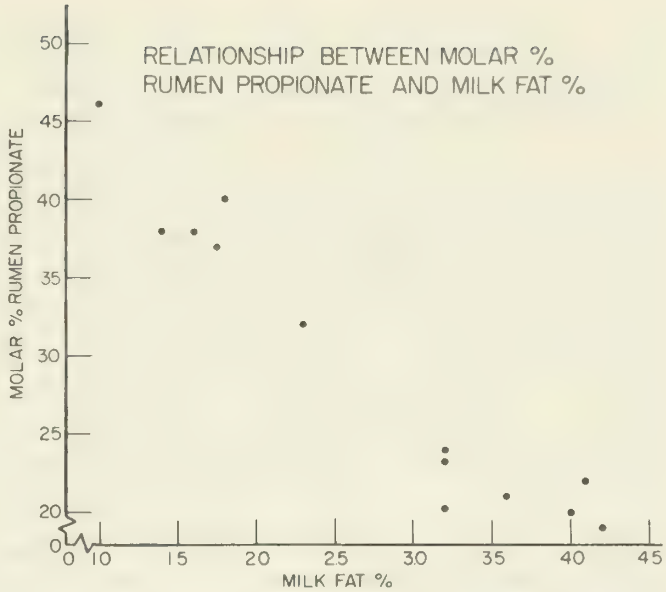


Figure 6. *Relationship between the proportion of propionate in the rumen and the milk-fat percentage.*

EFFECT OF WATER FLOW THROUGH THE RUMEN ON MICROBIAL FERMENTATION

When cows are fed high levels of grain along with limited amounts of roughage, the flow of water out of the rumen was much reduced compared to cows fed more conventional diets. In University of Illinois studies, for example, the average rumen-fluid dilution rate, expressed as the percentage of water in the rumen leaving per hour, was 9.6 percent per hour for cows fed a high-grain ration versus 20.6 percent per hour for the cows fed a conventional diet. Much of the difference can be accounted for by variations in the amount of saliva secreted.

When the fluid dilution rate in the rumen is low, the proportion of rumen propionate is high. As the dilution rate is increased by adding salts or buffers (stimulating a greater water intake or perhaps an increased saliva flow), the proportion of propionate in the rumen decreases.

Table 1 contains data obtained with lactating Holstein cows receiving a high-energy diet (75 percent concentrate, 25 percent corn silage, dry-matter basis) supplemented with either 2 percent sodium chloride, 2 percent sodium bicarbonate, or 2.4 percent limestone. These data clearly illustrate the points being discussed: that rumen pH and the rate of fluid dilution in the rumen control the mixture of fermentation acids produced which, in turn, affects the productive performance of the animal.

Table 1. *Effect of Adding Mineral Salt to the Diet of Dairy Cows on Water Intake, Efficiency of Feed Utilization, and Milk Production*

	Treatments			
	Control	Control + 2.0% sodium chloride	Control + 2.0% sodium bicarbonate	Control + 2.4% limestone
Rumen fluid dilution rate (%/hr.)	10.3	12.4	12.2	10.7
Rumen fluid outflow (liters/day)	112.0	128.9	119.2	112.5
Rumen fluid pH	6.0	6.0	6.2	5.9
Proportion of propionate in the rumen	38.9	32.0	25.2	37.5
Milk production (lb./day)	65.0	64.5	63.7	64.3
4% FCM (lb./day)	49.6	51.5	57.0	48.5
Milk fat (%)	2.4	2.7	3.3	2.3
Starch digestibility (%)	88.0	88.0	90.6	95.2

The outflow or dilution rate of fluid from the rumen also affects the flow of nutrients into the small intestine. Soluble nutrients or small feed particles that flow with the fluid phase can be washed into the small intestine by feeding mineral salts (sodium bicarbonate or sodium chloride), thereby improving the efficiency of feed utilization.

Feeding limestone has no effect on pH in the rumen, the flow of fluid out of the rumen, or milk fat tests: but does increase the digestibility of starch and improves the efficiency of feed utilization for milk production (Table 1). Therefore, adding mineral salts to the diet of dairy cows can alter the location of nutrient digestion and improve the efficiency of feed utilization. The salts also appear to benefit the lactating cow, especially during the early portion of that period.

Table 2. The More Commonly Used Buffers; Site of Action, and Feeding Recommendations for Lactating Dairy Cows

Buffer	Site of action	Feeding recommendations: Percent of grain mix	Feeding recommendations: Pounds per cow, daily
Sodium bicarbonate	Rumen	1.0 to 1.5	.25 to .5[a]
Magnesium oxide	Rumen	.4 to .8	.1 to .2
Sodium bicarbonate[b] + Magnesium oxide	Rumen	1.0 to 1.5	.3 to .6
Sodium bentonite	Rumen	5	1.5 to 2.2
Limestone (calcium carbonate)	Intestine	1.0 to 1.5[c]	.25 to .40

[a]Higher amounts up to 0.8 pounds per cow per day may be fed without a drop in feed intake if incorporated into a complete, mixed ration. [b]Mixture, 2 or 3 parts of sodium bicarbonate to 1 part magnesium oxide. [c]Should be about 2 times the phosphorus level in the diet.

Adding buffers to the ration should be considered for high-producing cows in early lactation and for young calves up to 3 months of age. Cows of average production and those beyond their peak lactation as well as heifers and dry cows are not likely to benefit from adding buffers to the diet.

Other situations in which feeding buffers should be considered are when: (1) the forage portion of the ration makes up less than 45 percent of the total dry-matter intake; (2) the total ration (forage and grain) has been chopped, ground, or pelleted; (3) top-producing cows are receiving grain at more than 2 pounds of grain (dry-matter basis) per 100 pounds of body weight; (4) the fat test of the herd is abnormally low and appears to be related to changes in the feeding program; and (5) frequent "off-feed" problems develop. The kinds of buffers to use and the recommended levels to feed are shown in Table 2.

NUTRIENT PROTECTION FROM BREAKDOWN IN THE RUMEN

Feed consumed by the cow is subjected to microbial fermentation in the rumen and to the cow's own enzymatic digestion in the true stomach (abomasum) and in the small intestine. The efficiency of feed utilization as well as the amount of milk produced can be altered by changing the part of the digestive tract in which the feed is digested. High-quality feed protein, starches, and sugars diverted into the lower gut and digested by the cow's enzymes are used more efficiently than if they had been degraded in the rumen by the microbes. The effective methods of regulating the site of feed digestion in ruminant animals are: (1) altering the solubility of the specific nutrient through chemical or physical means, or both; and (2) preparing analogs of specific nutrients.

PROTEIN PROTECTION FROM BREAKDOWN IN THE RUMEN

Protein metabolism in dairy cows is a very complex process. The complexity centers on the extensive degradation of dietary protein by the rumen microbes at the beginning of the digestive processes. Figure 7 shows the major changes that occur in dietary nitrogen as a result of microbial fermentation in the rumen. A majority of the rumen bacteria prefer ammonia as a source of nitrogen for growth and are active in converting nonprotein nitrogen and dietary proteins into ammonia (NH_3).

On the average, about 60 percent of the dietary protein in dairy feed is degraded in the rumen and contributes nitrogen to the ammonia pool. Most of the nonprotein nitrogen that enters the rumen is converted into ammonia. The efficiency with which bacteria in the rumen use ammonia for growth depends highly on the rates at which ammonia is formed and utilized by the microbial population. That growth rate depends, in turn, on the rate at which ammonia is formed and the total yield of energy from the breakdown of the feed.

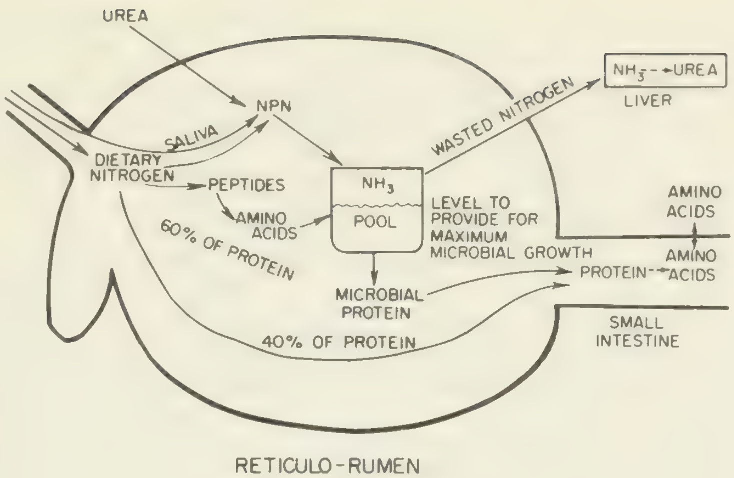


Figure 7. Nitrogen metabolism in the rumen.

Any ammonia not used by the microbes for growth is absorbed into the blood, made into urea by the liver, and excreted by the kidney.

About 40 percent of the dietary protein escapes microbial fermentation in the rumen and passes into the small intestine along with the microbial protein where both are digested by the cow's enzymes. Upon digestion, amino acids released from the protein are absorbed into the blood where they are used to synthesize tissue and milk proteins.

The best of all worlds for both the rumen microbes and the cow would be to provide the rumen microbes with a source of ammonia in the form of nonprotein nitrogen that becomes available at a rate which would support maximum microbial growth and would provide a dietary source of high-quality protein that is not broken down in the rumen and is digested in the small intestine by the cow. Such a feeding system would result in a more efficient use of protein and an increase in animal performance, especially for dairy animals during times of rapid growth and high milk production.

Figure 8 illustrates the relationship between amino acid needs for various body functions in relation to that supplied to the rumen microbes. The quantity of microbial protein supplied to the animal appears to be adequate for slow rates of growth, maintenance, early pregnancy, and very low levels of milk production. However, the amount supplied is inadequate to support rapid growth or high levels of milk production. When the protein requirement of the cow is greater than the quantity supplied by the rumen microbes plus the dietary protein escaping breakdown in the rumen, a source of protected protein or of amino acids would be likely to benefit the cow.

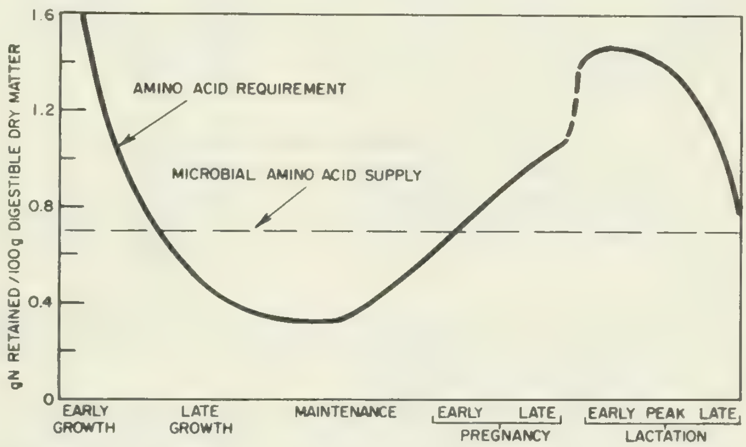


Figure 8. Effect of physiological state on amino-acid requirements in relation to digestible dry-matter intake and microbial amino-acid [Orskov, Proceedings, 4th Nutrition Conference for Feed Manufacturers].

Numerous factors affect the degradability of protein and amino acids in the rumen. These include the physical and chemical properties of the proteins, methods of feed processing and storage used, and chemical treatment of proteins—all of which affect the solubility of protein in the rumen. Encapsulating amino acids and the producing amino-acid analogs are ways of trying to prevent the breakdown of protein in the rumen.

Large differences exist among feedstuffs and within particular ones in terms of the extent to which protein is degraded in the rumen (Table 3). Urea, the main source of nonprotein nitrogen, is completely degraded in the rumen. Other proteins, such as the fishmeals, are degraded only slightly (10 percent).

with protein, solubility and degradability are not the same. A low solubility does not always indicate low degradability. For example, cottonseed meal is highly degradable, but has a low solubility. Therefore, protein degradability is a better indicator than protein solubility of the potential the protein has for escaping breakdown in the rumen and passing to the small intestine. In general, however, lowering the solubility of dietary proteins results in more protein escaping degradation by microbes in the rumen.

Table 3. Estimates of Degradation in the Rumen of Protein and the Solubility of Nitrogen in Various Feedstuffs

	Ruminal degradation	Soluble nitrogen
	percent	
Urea	100	100
Fishmeal	10 to 60	11
Cottonseed meal	60 to 80	7
Soybean meal	39 to 60	13 to 20
Barley	40 to 90	17
Corn	40	15
Red clover hay	32 to 60	26 to 28
Alfalfa hay	32 to 60	26 to 28
Grass hay	50	21 to 27
Corn silage	40	25 to 68

Formulating rations on the basis of protein solubility, or more specifically degradability, has the potential of improving the efficiency of feed utilization and increasing the milk production of dairy cows (Figure 9). In the study, 80 cows with an average of 17,600 pounds of milk in their previous lactation were fed different feedstuffs containing equal quantities of crude protein, energy, minerals, and vitamins. The diets varied only in the content of soluble protein (nitrogen times 6.25). Cows fed rations with less soluble protein peaked at a higher level of milk production, had a greater persistency of production, and produced more milk during the 10-week study. These results suggest that 10 to 20 percent of the total crude protein in the ration should be in soluble form, but no more than 25 percent.

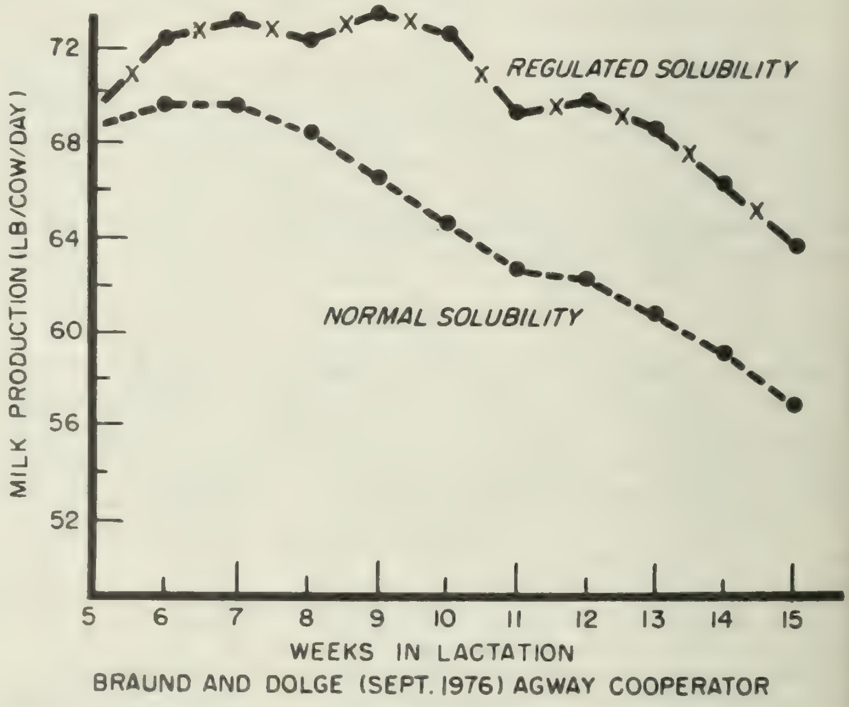


Figure 9. Effect of the solubility of the regulating protein on the milk yields of high-producing cows.

Many feed-processing methods either require or generate heat—altering the chemical nature of the protein and, thereby, lowering protein degradation in the rumen. The higher the temperature and the longer the heating time, the greater the resistance of protein to degradation in the rumen. However, the results of an Illinois study shown in Table 4 indicate that feeding diets containing heat-treated soybean flakes (20 to 30 minutes at 180° to 250° C.) did not increase milk production, milk composition, or the efficiency of feed utilization significantly.

Harvesting and storage conditions can greatly affect the degradability of the protein in haylage, too. Wilting hay-crop silage before ensiling reduces the degradability of the protein in the rumen. The cow's performance may be improved if the forage is not overwilted or overheated during the ensiling process. If feeds are overheated, however, the digestibility of the protein will be greatly reduced because of the chemical reactions between the protein and sugars as a result of the excess heat treatment. Hay-crop silages that have been overheated may have little or no feeding value as a source of protein because of their

Table 4. Average Daily Intake of Dry Matter and Crude Protein, Milk Yield, and Milk Composition for Cows Fed Heat-Treated Soybean Flakes

	Treatments[a]				
	S	W	X	Y	Z
Total dry matter intake (lb./day)	40.3	41.2	43.8	40.3	40.7
Crude protein intake (lb./day)	5.2	5.4	5.5	5.3	5.4
Milk (lb./day)	70.0	70.5	72.0	72.5	67.8
4% FCM (lb./day)	67.8	65.6	67.6	66.7	66.5
Milk fat (%)	3.80	3.62	3.66	3.56	3.86
Milk protein (%)	3.86	3.74	3.84	3.82	3.86

[a]Commercial soybean meal served as the protein supplement in diet S. The other four diets (W, X, Y, and Z) contained defatted soybean flakes heated at 250°, 250°, 215°, and 180° C. for 30, 20, 20, and 25 minutes, respectively. The soluble nitrogen contents of the diets was: S, 18.8 percent; W, 17 percent; X, 18.8 percent; Y, 26.5 percent; and Z, 30.6 percent.

greatly reduced digestibility. Thus, commercial efforts to prepare heat-treated proteins in order to achieve protection from microbial degradation in the rumen is difficult because of the likelihood of over heating.

PROTEIN FEEDING RECOMMENDATIONS

Our current recommendations on feeding proteins are as follows. During early lactation, dairy cows should be fed diets containing crude protein at 14 to 16 percent of the dry matter in the ration. If the dry-matter intake is low and the protein cost is favorable, the crude protein content can be increased to 17 or 18 percent. Do not feed nonprotein nitrogen in early lactation when the cow requires a diet containing 13 percent or more crude protein. The crude-protein content of the diet can be reduced to 13 percent after the milk yield drops below 50 pounds per day. If economically justified, nonprotein nitrogen can be used in dairy rations according to recommended guidelines or the manufacturer's recommendations. Formulating rations based on protein solubility may be profitable, but additional research is needed before recommendations can be made for using protected proteins and amino acids in the rations of dairy cows.

FUTURE POSSIBILITIES FOR PROTECTING PROTEINS AND AMINO ACIDS

Treating protein with a variety of chemicals will decrease the degradation of protein by microbes in the rumen. The chemical bonds formed are stable at a pH of 5 to 7, which is typical of the conditions in the rumen.

As the treated protein passes from the rumen to a more acid environment in the abomasum (a pH of 2 to 3), the chemically treated proteins become available for digestion by the cow.

In U. of I. studies, feeding formaldehyde-treated protein has not always increased milk yields, improved milk composition, or produced greater efficiency in feed utilization. However, these factors have been improved in recent studies.

When formaldehyde at 0.3 to 0.4 percent was fed to cows in early lactation, research has shown increased yields of milk by 4 to 7 percent; protein, by to 6 to 8 percent; and fat, by 3 to 8 percent. The lack of response in many of the earlier studies may have come about because the cows were past their peak in milk production. So, those cows probably did not require protected protein in their rations in order to meet their requirements.

Hence, protected proteins may only increase milk production during the first 100 to 120 days of lactation. Undertreatments or overtreatments of the protein with formaldehyde also may have produced inconsistent results by making the protein less digestible in the small intestine. Three major obstacles must be overcome before this method of protein protection can be used for feeding dairy cows. We will have to establish a suitable level of treatment. A proper method of treatment will have to be determined. Approval must be obtained from the Food and Drug Administration for feeding the treated protein.

AMINO ACIDS: PROTECTION FROM BREAKDOWN IN THE RUMEN

Several amino acids may be deficient in the metabolism of high-producing lactating dairy cows. Methionine is considered as one of the most-limiting amino acids for the synthesis of milk protein.

The methods of preventing the destruction of the amino acids in the rumen include encapsulation with materials resistant to microbial attack and the preparation of amino acid analogs, as noted previously. The biggest disadvantage of encapsulation has been the cost of the process. More-economical encapsulation methods are available now; but as yet, the products have not been approved by the Food and Drug Administration for use with dairy cattle.

The major amino-acid analogs that have been investigated are α-hydroxy-γ-methylmercaptobutyric acid (MHA) and N-hydroxy-methyl-L-methionine-calcium (HMM-Ca). MHA appears to be more resistant to microbial degradation than methionine. Even so, substantial amounts of MHA are broken down in the rumen. Feeding MHA to dairy cows has not consistently increased milk yields. Feeding HMM-Ca or HMM-Ca plus protected protein increased milk yields by 7 to 10 percent and milk-protein yields by 10 to 12 percent in one study. However, that analog has not been approved by the Food and Drug Administration for feeding to dairy cows.

The greatest responses from feeding amino-acid analogs have been recorded during the first third of lactation. In order for an amino-acid analog to be beneficial for dairy cows, it must: (1) be the most-deficient amino acid; (2) escape degradation in the rumen; and (3) be absorbed from the small intestine into the blood stream.

The shortcoming of using analogs to prevent degradation of amino acids in the rumen is that each analog contains only one amino acid and each amino acid, starting with the most-deficient one, provides only a small increase in milk yield. Therefore, a measurable increase in milk production may not be detected until several protected amino acids are included in the dairy ration.

FAT: PROTECTION FROM BREAKDOWN IN THE RUMEN

High-producing cows in early lactation usually do not have enough energy because they cannot consume enough feed to meet their energy requirements. Substituting substantial quantities of grain for forage to increase the energy content of the ration results in diets that do not contain enough fiber. This change results in high acidity in the rumen (a low pH value), decreased fiber digestibility, low milk-fat tests, and more frequent off-feed situations. Substituting fat for a portion of the grain increases the energy content of the ration without decreasing the fiber content. However, only 3 to 7 percent of the nonprotected fat can be added to the diet without causing negative effects on feed intake and digestibility, rumen fermentation, and milk-fat tests.

Protecting fat from microbial breakdown in the rumen by coating it with protein and treating with formaldehyde may be an effective method of increasing the energy content of the ration without causing determental effects. Feeding protected fat to lactating cows during the first 100 days of lactation has increased milk-fat tests (Table 5) and may increase milk

Table 5. Effect of Feeding Protected Fat on Milk Production and Milk Fat Percentages During Early Lactation

	Trial 1[a]		Trial 2[b]		
	Control	Protected fat	Control	Protected fat (15%)	Protected fat (30%)
Milk (lb./day)	49.6	47.7	68.9	68.1	66.1
Fat	3.44	3.84	3.38	4.28	4.48
4% FCM (lb./day)	45.4	46.6	62.3	70.7	70.9

[a]Adapted from Kronfeld *et al.* (1980). *J. Dairy Sci.* 63:545. Data are for weeks 6-26 of lactation.

[b]Adapted from Smith *et al.* (1980). *J. Dairy Sci.* 61:747. Data are for weeks 1-15 of lactation.

yields if the supply of energy does not meet the needs of the cow. Even if feeding fat fails to increase milk production and milk-fat tests, doing so may benefit the cow by reducing the incidence of ketosis.

SUMMARY

Although numerous methods of managing the action of the rumen are in various stages of research and development, the dairy producers currently has only two means of adjusting rumen fermentation that will increase milk production, improve the efficiency of feed utilization, or both: (1) selecting feeds that optimize rumen fermentation and maximize the flow of nutrients out of the rumen and into the small intestine; and (2) supplementing the ration with mineral salts, which increases the efficiency of rumen fermentation and changes the location of digestion. Research results have been promising in terms of improving milk yields, fat tests, and feed-utilization efficiency, as well as reducing metabolic disorders when selected chemicals or protected proteins, amino acids, and fat were fed. However, products for such uses have not been approved by the FDA for feeding to dairy cows.

Transfer of Immunity to the Calf Through Colostrum

BRUCE L. LARSON

THE RECOMMENDATION THAT EVERY CALF SHOULD RECEIVE COLOSTRUM during the first hour after birth is a practice long used by successful dairy producers. Adhering to this practice is a major factor in reducing calf mortality. However, careful attention is needed to ensure that each calf receives colostrum early. Left to themselves, many calves will wait several hours before suckling. Also, some cows may produce inadequate amounts of colostrum while others produce an excess. Balancing the amounts available between calves is desirable.

Current research in the Department of Dairy Science is providing new information about the role of colostrum and its importance in calf feeding. We are learning more about how colostrum is formed in the cow and is utilized by the newborn calf.

Species of animals differ in the means by which maternal immunity is transmitted to the offspring, protecting them in the critical period after birth while their own immune systems are being established. Cows are part of a group of species (cows, sheep, goats, deer, horses, and pigs) that transmit passive immunity to their offspring after birth through antibodies present in the colostrum. Another group of animals (rabbits and humans) transmit antibodies to their offspring before birth via the placenta. A third group of animals (dogs, cats, and rats) transmit antibodies to their offspring by both methods.

A few weeks before parturition, large quantities of immunoglobulins begin to leave the blood stream of the cow to accumulate in the mammary gland, appearing in the colostrum at parturition. Colostrum usually contains 2 to 3 times the amount of total solids present in normal milk. The increase is due mainly to greater amounts of proteins being present, although the fat content also tends to be higher. Less lactose is found in colostrum than in normal milk, which is helpful because high-lactose diets tend to promote scours. The total content of minerals and vitamins is also higher than in normal milk, with an increase of several fold in iron and vitamin D and up to 10 times more vitamin A. The most outstanding characteristic of colostrum, however, is its high content of immunoglobulins—the proteins which contain antibodies that protect an animal from various diseases.

The immunoglobulins in bovine colostrum are composed of 3 main classes with slightly different structures and functions—IgG, IgA, and IgM. The IgG class, the most important in bovine colostrum, is further divided into 2 closely related subclasses, IgG1 and IgG2. Both of these are present in colostrum, but IgG1 is predominant—being about 7 times more concentrated than IgG2 in colostrum, even though their concentration in the maternal blood stream is about the same.

The newborn calf does not have any appreciable amount of immunoglobulins to protect itself from disease and must rely on colostrum for its supply. The calf must receive a sufficient quantity of these immunoglobulins very soon because it is exposed at birth to disease organisms that gain entrance at the various body openings. If the calf does not receive protection before the disease organisms become established, its chances of survival are greatly reduced. When the calf consumes the colostrum, the immunoglobulins perform a protective role in the gut against disease organisms. In addition, some of the immunoglobulins are absorbed through the intestinal wall into the blood stream of the calf, thereby giving protection to the body. The ability of the calf to absorb proteins across the intestine into its blood stream begins to diminish shortly after birth and is essentially gone after about 24 hours, when "closure" takes place.

In the calf, the transfer of immunoglobulins across the wall of the gut is rather nonspecific for different types of proteins; but in the cow, the transfer of immunoglobulins from the blood stream into the colostrum is a highly selective process for IgG1. Through studies now in process at the University of Illinois, we are trying to delineate the detailed mechanism by which this transfer occurs.

For years, immunoglobulins from the mother's blood were thought to seep somehow or to be filtered out of the blood and into the colostrum. Recent studies, though, indicate that the immunoglobulins leave the blood stream to enter and be carried across the same cells that synthesize and secrete the components of milk. The details of this transport process for the immunoglobulins are of great biological importance in helping to explain how certain large proteins are transferred across cellular barriers. So far, we know that the transport process for IgG1 in the bovine mammary gland involves certain "receptor" proteins that are specific for IgG1 and that exist on the surface of the milk-producing secretory cells. The IgG1 molecules bind to the receptors and then are pulled into the cell, moving through the cell by a specific route which has not yet been discovered. To delineate this route through the specific small organelles of the individual cells requires many detailed biochemical procedures coupled with high-power electron microscopic techniques. These are in progress currently.

Now, let us consider some of the important factors that influence the establishment of passive immunity in the calf.

1. Each calf should receive an adequate amount of colostrum within the first hour after birth, or as soon as practicable. Many calves will delay nursing their dams for many hours after birth. A calf that does not nurse within an hour should be helped to do so or else fed colostrum from a stored source. The blood level of IgG1 cannot rise in the calf until it has consumed colostrum. The earlier this happens, the better. About 3 or 4 pounds of colostrum should be enough when fed in this early period. The colostrum results in a rapid rise in the blood levels of IgG1. More colostrum is required if the first feeding is delayed. The first milkings of colostrum obtained within 12 hours after calving contain the most IgG. Each subsequent milking contains less; and after 24 hours, only small amounts of IgG remain.

2. The ability of the newborn calf to absorb immunoglobulins across the gut wall and into its blood stream diminishes rapidly after about 12 hours; and after about 24 hours, is essentially gone. The rate and time of closure vary among calves and may be delayed somewhat in calves that did not receive enough colostrum early. Such calves may benefit somewhat from continued colostrum feeding; but for a high blood level or for absorbed IgG, there is no substitute for early feeding. Feeding colostrum for up to 3 days is recommended if it is available. Doing this has a continued, beneficial effect on combating disease organisms within the intestine.

3. Some studies have suggested that calves which remain with their dams establish higher blood levels of IgG than those which are separated and are fed the same amount of colostrum by hand. However, removing the calf early and handfeeding ensures that each calf is fed the proper amount of colostrum on the proper schedule. Each dairy producer should establish a routine procedure. The important thing is to see that each calf receives an adequate dose of colostrum soon after birth.

Excess colostrum can be saved and stored for long periods by freezing; for shorter periods of a few weeks, by keeping it in a refrigerator; and for still shorter periods, by storage

at room temperature. Colostrum sours (ferments) quickly when stored at room temperature. The taste becomes acid, which some calves will reject. Fermented colostrum can still be utilized. At feeding time, dilute it with about half its volume of water and neutralize the acid by adding about 1/7th of an ounce (4 grams) of sodium bicarbonate to each gallon of the diluted colostrum.

The best of passive immunity derived by the calf from colostrum needs to be coupled with good sanitary practices. Following sanitary procedures for the cow and calf at the time of birth—such as providing a clean, dry, and sanitized pen—reduces the exposure of the calf to disease organisms. Such care coupled with proper colostrum feeding should return an ample reward to the dairy producer in terms of reduced incidences of debilitating scours and death among the calves.

Strategies for Herd Improvement–The University Herd

S.L. SPAHR AND G.C. McCOY

UNIVERSITY HERDS ARE MAINTAINED FOR MANY PURPOSES and are used in a variety of ways. Hundreds of people visit the dairy herd at the University of Illinois every year. Each group sees something different. Local school children come to pet baby calves and see how a cow is milked. The parents of students come for a visit and to see new methods in the technology of milk production. Dairy producers from all over the state visit the herd and are impressed or unimpressed, as the case may be, by the particular animals they see during their visit.

OBJECTIVES FOR THE UNIVERSITY HERD

The operational objectives for the University of Illinois herd are unique among all of the dairy herds in the state. Research is the greatest single category of use for the University herd. Research requests for animals vary widely. Researchers may need groups of Holstein cows in the second lactation and later, freshening at the same time as nearly as possible, for a full lactation study. Other researchers may need a group of cows in early lactation that are housed together in order to test new ways of detecting estrus or of diagnosing pregnancy.

Recent requests for animals have been for studies concerning new ways of detecting and treating mastitis, new technology for embryo recovery and superovulation, a new treatment for soybean meal to improve protein utilization, and an attempt to improve the resistance to mastitis by inserting an intramammary device. Between August 1, 1979, and July 1, 1980, some 23 requests, including those just mentioned, were made for research purposes in connection with the University dairy herd.

The herd also is used extensively for teaching. Routine dairy management practices are demonstrated through various courses and programs. Each semester, about 15 animals are used for practice concerning artificial insemination and reproduction. Animals are used for judging classes in the spring; also, for judging contests for the Dairy Science Club, Illinois FFA program, Illinois 4-H program, and specialized practices for dairy judging teams from across the United States before the contests held in the fall. In addition, the herd is the primary facility for veterinary students as they learn how to provide preventative animal health care. Against this multifaceted background, strategies for improving the University herd have been developed over the past decade.

A BRIEF HISTORY

The University herd has produced some outstanding and well-known animals over the years. Illini Nellie, the most famous one, brought the University a great deal of publicity in the late 1930's. During the late 1960's, Illini Jim Millie DC set a national record for milk for the junior 4-year-old class. She produced 28,530 pounds in 305 days and came back to produce over 32,000 pounds of milk and 1,100 pounds of fat in her next lactation (Table 1).

Table 1. University of Illinois Holstein Production Leaders, 1965-1980

	Age	Days	Year	Milk (lb.)	Fat	Class leader, when made
Illini Jim Millie DC	4-2	305	1967	28,530	834	1st Milk, U.S.
	4-2	310	1967	28,750	842	1st Milk, Ill. 365 days
	5-2	305	1968	29,780	1,016	2nd Milk, Ill.
Illini Jim Sybil	3-2	305	1968	23,080	707	3rd Milk, Ill.
	4-4	305	1969	26,890	633	2nd Milk, Ill.
Illini Jim Edna	4-2	305	1966	25,379	734	2nd Milk, Ill.
Illini Bootmaker Eve	2-1	305	1978	21,330	897	2nd Fat, Ill.
Illini Elevation Connie . . .	2-9	365	1979	28,010	687	3rd Milk, Ill.
	4-5	358	1980	27,120	712	Incomplete

One of her sons, Illini Fond Billy, was used extensively in artificial insemination. Illini Coronet Midge was the reserve All-American 3-year-old in 1968 and was the youngest Holstein ever to be scored 95 points. As Table 1 shows, other outstanding animals could be cited; but generally, the herd did not have the reputation of an elite breeder herd during the 1960's and 1970's.

HOLSTEIN STRATEGY

During the early to mid-1970's, a strategy evolved for herd improvement. A dairy-beef project existed in the early 1970's, one which specified that at least 60 units of semen should be purchased and used in the Holstein herd from each bull that was selected. This number was later increased to 120 units per bull. Semen was purchased nationwide and from Canada in an effort to improve the gene pool in the herd. A few Holstein cows were purchased, but the strategy was to use the available money for herd improvement to buy semen from top-quality sires, rather than to buy individual animals since the ultimate impact would be greater.

Individual matings were specified for the first two services for each cow and heifer. In order to keep costs in line and to maximize the use of the limited supply of semen available from the bulls, a switch was made to the use of a "cleanup" AI bull with the third service. In the early to mid-1970's, the cleanup AI bulls were young ones. To minimize the cost, they were selected by their pedigrees. About 4 years ago, the criteria for the selection of a cleanup AI bull was changed to a "cold" pedigree, that is, to the use of readily available proven bulls. This change was made because a relatively large number of animals being born were sired by the cleanup bulls. Our batting average for selecting the outstanding young bulls by pedigree was unimpressive. Ultimately, few of the bulls selected in this way turned out to be good enough to continue in AI service after their summaries became available. Thus, this practice was having a significant impact on the herd improvement program.

By selecting cleanup AI bulls according to their progeny test information, we have raised the rate of genetic improvement (Table 2). During the last 3 years, we have concentrated more on bulls with high predicted differences for type for use as cleanup AI bulls, ones with outstanding production credentials but low repeatabilities and a low cost before becoming popular. Our experience in this regard both with cleanup bulls and regular-service bulls has been very good. Our breed adjusted average has gone from 97 in 1975 to 101 in 1979. Compared to the young sires, we consider it much easier to locate an elite bull with a few daughters using today's sophisticated tools of technology concerning the predicted difference for milk and type supplemented by reports from the AI organizations. While a few losers may be cited, we are particularly happy with our choices of S-W-D Valiant and Glen Valley Star, based on their initial summaries. Since the amount of information available has already been considered in the calculation of the predicted difference for milk and the predicted difference for type, we accept high predicted differences—even with a low repeatability—in our selection procedures.

Table 2. Illini Holstein Progress During the Last 6 Years

Classification			DHIR average			Average PD[a] for sires of heifers		
Year	No.	BAA	No.	Milk (lb.)	Fat	No. of calves	PD milk	PD type
1975	...	...	181	13,698	500	79	+ 546	+0.60
1976	165	97.7	176	14,652	541	80	+ 730	+0.34
1977	193	99.7	172	16,232	581	90	+1,217	+0.63
1978	182	100.3	170	16,812	649	81	+1,268	+1.02
1979	200	101.0	176	16,865	601	96	+1,422	+1.86
1980	...	...	169	17,139	598	67[b]	+1,469	+1.65

[a]January, 1980 PD's. [b]Total to date.

The present criteria for the selection of new sires are minimum scores for his daughters on PD milk of +1,400 pounds, PD type of +1.5, and a minimum TPI of approximately +500. Some attention is given to percent fat, too. A bull with a PD fat percentage of less than -.10 must be very elite to be selected. The main type criteria is PDT; however, some emphasis is also given to the specific traits of the mammary system, feet and legs, and stature. During the last 2 years, we have concentrated on keeping the genetic base broad due to the very large proportion of Round Oak Rag Apple Elevation and Pawnee Farm Arlinda Chief sons at the top of the list. While following this program, our DHIR average has increased almost 4,000 pounds for milk and 100 pounds for fat.

A few of the most outstanding members of the herd are selectively mated, but the strategy has been to depend on semen from a battery of outstanding bulls that were improving in terms of both type and production, instead of placing a great deal of emphasis on individual mating. From these matings (Table 2), the average PD's for milk and type of sires of calves born in the University herd have tripled over the past 5 years. A main factor considered in each mating is to try to avoid having the same animal appear twice in a three-generation pedigree.

The selection of a cleanup AI bull with a relatively cold pedigree has been an interesting challenge. Outstanding individuals that are outcrosses to the general lines present in the herd have appeared in each new sire summary. With the turnover of animals in the herd, it is possible now to bring in sons of bulls that were used during the mid-1960's and to use them extensively without violating our guideline for maintaining a broad genetic base.

COLORED BREEDS

The University has maintained 20 to 25 Brown Swiss and 10 to 15 milking cows of the other breeds over the last decade. During the cost-price squeeze of 1974, we seriously considered eliminating one or more of the colored breeds. Instead of selling the breeds, the decision made then was to maintain each breed but to improve the quality of the animals by some purchases. This decision was based on the fact that their primary use is for teaching and in the conduct of the FFA and 4-H judging contests during the summer.

Over the last 6 years, a number of quality animals have been added through purchases by private treaty and at sales, primarily from state breed sales and the Kentucky National sale series. At the same time, an extended effort has been made to obtain outstanding semen from proven bulls.

The daughters and granddaughters of such outstanding bulls of the last decade as Welcome in Stretch (Brown Swiss), Norvic Lilason's Beautician (Brown Swiss), Clovelly Top Hornet (Guernsey), Western Glow Darimost (Guernsey), Milestones Generator (Jersey), Vaucluse Sleeping Surville (Jersey), Oak Ridge Flashy Classic (Ayrshire), and several sons of Selwood Betty's Commander (Ayrshire) make up the bulk of the cows presently in the herd for the breeds indicated.

SEMEN COST

Our difficulties with breed improvement in Holsteins have included the limited availability of semen from some bulls and the high cost for semen from many of the bulls. Generally, we have continued to buy semen from the outstanding proven bulls as long as the bull was still

alive and producing semen. Much of the Holstein semen purchased over the last 5 years has cost $15 to $40. Usually, we have rejected the purchase of semen from bulls after they were dead and the price doubled from a previous value. So, the inventory of semen being used is almost all from bulls still available at routine prices.

The cost and availability of semen from bulls in the colored breeds has been different. The problem there has been to decide which bulls were the elite ones. The cost of semen rarely has exceeded $12 to $15 per unit, as long as the bull was alive and was producing semen.

Mastitis Prevention: The Role of Plastic Loops and Sanitation

E.H. JASTER

MASTITIS IS A COSTLY DISEASE that afflicts more than half of the 10.7 million dairy cows in the United States. Sooner or later, dairy cows will have some form of mastitis in one or more quarters. The estimated annual losses from mastitis average $200 per cow, according to recent reports, with the total loss exceeding $1 billion per year.

ANTIBIOTIC RESIDUES

Mastitis usually is treated with antibiotics. However, these compounds are coming under renewed scrutiny. As of July 1, 1980, the Food and Drug Administration requires that a new antibiotic test be used for monitoring the adulteration of milk. With the *Bacillus stearothermophilus* procedure, the presence of penicillin in concentrations of 0.006 IU per milliliter can now be detected. The test is 10 times more sensitive than the one used previously, the *B. subtilis* test.

Antibiotic residues in milk are associated with the treatment of mastitis and other diseases in dairy cows. If the milk of treated cows is marketed too soon after treatment, antibiotics may be present in the milk. Because of the new test, more milk undoubtedly will be withheld from the market than in the past.

Antibiotics for treating mastitis have been a help to dairy farmers. But the rising costs of the drugs, greater losses from discarded milk, and declining effectiveness of antibiotic treatments in some cows present significant problems. A possible alternative would be to control mastitis without using antibiotics.

USING PLASTIC LOOPS

Controlling mastitis without antibiotics involves altering and manipulating the naturally occuring factors in milk secretions associated with the cow's defense system. The plastic loop is one alternative that may help prevent mastitis.

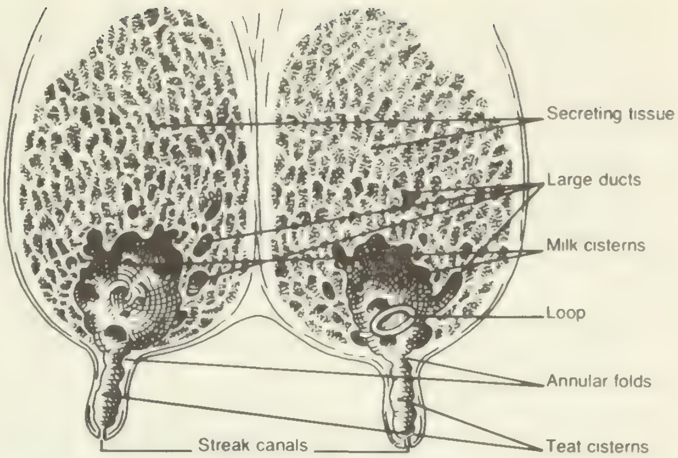
The loop device is made of polyethylene plastic. It is about 5 inches long and 1/8 inch in diameter. It takes a circular shape when inserted into the udder cistern of each quarter (Figure 1). Once in place, the loops seem to cause a mild irritation, subsequently increasing the number of leukocytes (white blood cells) in the gland.

During a process known as phagocystosis, the white blood cells "recognize" chemical messengers that signal an invasion of bacteria. These messengers, formed from damaged cells of bacteria, cause large numbers of leukocytes to move into the irritated or infected area. There, they engulf the pathogen and kill it with destructive enzymes and proteins.

Normally, this process occurs 24 hours after the invasion of mastitis-causing bacteria. If the bacteria multiply before the leukocyte response, however, that allows the bacteria to become established in the udder. By causing a mild irritation in each quarter, the loop increases the normal leukocyte levels before invasion. Thus, a greater number are on hand to destroy the invading bacteria, thereby reducing the time needed for the udder to respond to infection.

Preliminary research is being conducted at the University of Illinois Dairy Research Center to determine whether the plastic loop will cause a localized formation of leukocytes and if so, whether the increased response will prevent mastitis. The loops already have been inserted into 2 teats of 10 first-calf heifers. All 10 calved recently. The heifers have no history of mastitis. Eventually, 20 lactating heifers will be used in the study.

Initial results from the first 3 months of data collection indicate that the number of leukocytes has increased in the teats containing the loops. This finding is based on samples of foremilk, bulk, and strippings taken from all 4 quarters of the 10 lactating heifers. (Foremilk is the first milk; strippings, the last milk obtained during milking. Bulk is a composite sample.)



Above: This diagram, illustrating a vertical (left) and horizontal (right) view of an udder, shows the loop position in the mammary gland (PN-4195).

Above Right: Leucocytes, white blood cells, are stimulated by the loop and attracted into the mammary gland, where they attack and destroy Staphylococcus aureus, the mastitis-causing bacteria (PN–4191).

Figure 1. Position of the loop in the mammary gland.

Bacteriological analyses of aseptically collected foremilk samples are being used to monitor the heifers for clinical and subclinical mastitis. Preliminary counts show a significant increase in the number of leukocytes produced by the treated quarters (Table 1). So far, the loop has not affected milk yields, the percentages of milk fat and protein, or the electrical conductivity of the milk.

Table 1. Leukocyte Counts in Various Fractions of Milk from Quarters With and Without Plastic Loops[a]

Fraction measured	No loop (control)	Loop
	cells per milliliter	
Foremilk	189,000	1,496,000
Bulk	141,000	827,000
Strippings	397,000	2,169,000

[a]Each value represents the mean from 10 animals.

The response of the udder with loops to the infusion of mastitis-causing bacteria will be studied, too. The objective will be to determine whether an increase in the number of leukocytes is sufficient to prevent the bacteria from becoming established in quarters containing a loop. Cows with a history of mastitis may have a delayed reaction to the loop. Additional tests are needed before the loop can be recommended for mastitis prevention and made available to dairy farmers.

SANITATION

Good sanitation is still paramount in mastitis prevention. Great care should be taken during milking to reduce the transmission of pathogens from the milker's hands, udder wash cloths, and milk-machine test cups to the udder. Bacteria can also be transmitted when the cow licks its teats and udder or when the teats come into contact with the rear legs, tail switch, flies, and contaminated bedding. Several sanitary practices are necessary for effective control.

1. DISINFECTING THE MILKER'S HANDS. Research in England has shown that the use of disinfectants or rubber gloves reduces the number of pathogens on the hands of milkers.
2. WASHING THE UDDER. Washing udders with a sanitizing solution removes dirt and organic matter, destroys mastitis organisms, promotes milk letdown, and improves milk quality.

An excessive use of these solutions should be discouraged, though, because pathogens can be spread rather than destroyed on udders that are wet. Single-service towels or heat-sterilized cloths should be used to dry the udder before teat cups are attached.

3. DISINFECTING THE TEAT CUPS. Disinfecting the cup liners before use on each cow reduces the number of pathogens transferred by the milking machine, according to research in the United States and England.

4. DIPPING THE TEATS. The use of disinfectants after milking will destroy pathogens remaining on the teats. Louisiana researchers recommend that teat coverage be sufficient to reduce any new intramammary infection.

The Promise of Electronic Identification

SIDNEY L. SPAHR

DEVELOPMENTAL ENGINEERING CONCERNING THE DESIGN OF NEW TECHNOLOGY for dairy farm equipment has resulted in a number of recent advances in automated equipment for feeding and for use in the parlor. Electronic identification for cows is one research development that seems about ready to have a major impact on dairy management practices. Scientists in the United States and Europe have been testing such units, and they are now available commercially.

Several companies are offering automatic feeding systems in which the cow wears an electronic identification unit (a transponder) around her neck or strapped to her leg. In a typical situation, an automatic grain-feeding stall is located in the lot or in a free-stall barn. The cow enters the stall, is identified automatically, and is given grain dispensed according to an amount preset on a microprocessor located in the manager's office. The microprocessor is connected to an automatic feeder by cable. The microprocessor records the number of times the cow comes into the feeder and keeps a cumulative total on the amount of grain dispensed to her each day. The system automatically spreads out her grain allocations into several meals per day.

That is only one example of the many uses for electronic identification. In the dairy-management research program at the University of Illinois, we are testing and developing ways of using electronic identification in the parlor and in group housing situations.

There are two approaches to electronic identification. One is to use a transponder permanently implanted underneath the cow's skin. Such units also can monitor her temperature. This technology was developed at the Los Alamos Scientific Laboratory in New Mexico and was designed to improve health monitoring as well as to provide electronic identification. The units, encased in plastic, are about 4 inches long, 1/2 inch wide, and 1/4 inch thick. They are solid-state electronic devices, designed with sufficient identification capacity to include the entire population of cows in the United States.

A second approach to electronic identification utilizes units that are strapped to the cow around the neck or the leg. The first ones offered for automatically feeding individual cows were neck units. Milking machine companies are now offering such units for automatic identification in the parlor as well as complete systems to automatically identify each cow, measure the milk received, and record the milk weight at every milking. The identification unit that straps around the leg has a pedometer built in to measure the cow's activity as an aid in detecting estrus.

We have been involved in extensive tests on the units that are implanted. Presently, we have one group of 20 heifers with implants and a group of 40 cows with units worn around the neck. With the heifers, the units were surgically implanted just behind the shoulder underneath the skin on the left side. The units were implanted in October of 1979. The monitoring started in March of 1980. Monitoring devices were set up to identify the animal and to determine her temperature every time she came to the waterer. Thus, the number of times she drank water determined the number of times she was monitored daily.

The units could be readily identified at 15 to 20 feet before being implanted. Subdermal implantation greatly reduced that range. It was necessary to have the antenna as close as 2 feet away from the animals in order to obtain consistent readings on all of the heifers. The subdermal temperature of an animal follows the diurnal temperature of the day, varying from one day to another depending on the ambient temperature. The large differences recorded suggest that the temperatures of all animals will have to be taken at a standard time each day, for example at milking time; also, the animals that are different will have to be picked out from the other animals that day in order for automatic temperature monitoring to become part of routine herd management.

Electronic identification is the first step toward an automatic recordkeeping system on the the data for dairy cows. The technology is now available to design a system for automatically recording weights in the milking parlor daily. One of the questions we will be studying during the next year is whether we must have an identification antenna at each milking location, or whether we can monitor the cows as they enter a group of herringbone stalls and have the computer keep track of their order as they are milked. Electronic identification can be matched with electronic milk-flow meters or with weigh-jars mounted on electronically read strain gauges to measure the amount of milk produced daily.

Using the electrical conductivity of the milk, we may be able to monitor each cow for mastitis by matching electronic identification with the electrical conductivity of each quarter. A prototype system for doing this has been constructed and tested successfully at the University of Illinois. With this approach, we hope to be able to locate mastitis at an early stage of development and to treat it before major damage to the udder occurs.

The electronic identification units made for implantation underneath the skin also could be used to monitor the cow's temperature. As yet, we do not know whether temperature variations caused by estrus or by mastitis will be great enough to be of much benefit in routine herd management. However, elevated temperatures for a particular cow usually are an indication of some type of illness. So, our approach should help improve the identification of problem animals in large herds.

Electronic identification allows the dairy producer to bring back some individuality to cows that are handled in groups. When combined with a microprocessor, electronic identification can be a valuable management aid. It can help with routine monitoring or measurement of data concerning an individual cow. A microprocessor, or minicomputer, can analyze what is happening to a cow on the day that it happens, rather than afterward.

Some likely uses will be to measure milk yields and to automatically control the amount of feed dispensed, based on the milk yield for the previous 7 or 10 days. Microprocessors hold the promise of being particularly important for use in feeding individual cows when housed in groups. Electronic identification combined with an automatic feeder and microprocessor can also register how many times a given cow came to the feed stall, how much feed was dispensed, and what the performance profile of that cow is day by day.

The systems described here are not in widespread use. However, they are rapidly becoming available commercially and are likely to be popular among dairy producers in the near future as the reliability of the systems is confirmed through the field testing.

Estrus Activity in Lactating Cows During the Postpartum Period

C.N. GRAVES AND J.R. LODGE

PROFITABLE DAIRYING DEMANDS high reproduction efficiency, resulting in a short calving interval and high milk production. A calving interval of 12 months is considered optimum because that interval allows for the highest daily production over several lactations and the greatest return over feed costs. A 12-month interval can be achieved after calving only if the dairy cow: (1) returns to a normal ovarian cycle; (2) reestablishes a normal uterine environment; (3) is detected as being in estrus; and (4) conceives in less than 90

days. Although for most dairy cows a normal cycle is resumed and the uterus returns to its regular size within the first month, many animals still do not attain the interval of 90 days or less between parturition and pregnancy. Since they are not detected as being in estrus, they are not bred.

To investigate this problem, 28 Holstein cows calving between February 1 and May 1 with no complications associated with calving were placed in free stalls within 6 days of calving. There, they could be watched for signs of estrus. All cows were observed 3 times a day for behavior that would indicate estrus and were outfitted with Ka Mar heat-detector tags. An androgenized heifer fitted with a chin-ball marker was used to help detect cows in estrus. The ovaries of each cow were palpated via the rectum 2 or 3 times each week in order to follow ovarian changes in relation to the visual observations. Milk samples were taken daily from each cow and were analyzed for progesterone to further check for ovarian activity. All criteria were followed on each cow until 55 days postpartum.

The results are given in Table 1.

Table 1. Behavorial Signs of Estrus in Cows after Calving, by Age

	percent
All cows	
Estrus by 30 days postpartum	46
Estrus by 40 days postpartum	75
Estrus by 89 days postpartum	89
First-calf heifers (primiparous)	
Estrus by 40 days postpartum	63
Estrus by 55 days postpartum	75
No evidence of ovarian activity (anestrus)	19
Cows with 2 or more calvings (pluriparous)[a]	
Estrus by 40 days postpartum	92
Estrus by 50 days postpartum	100

[a]No cows in the pluriparous group were classified as anestrus. Over half of the cows displayed estrus behavior twice during the 55-day period.

Based on the milk-progesterone profiles, records of behavior, possible signs of estrus, and evidence obtained by palpatating the ovaries, 15 of the 28 cows (54 percent) exhibited signs of estrus before the first postpartum ovulation; and 12 of the 15 cows showed estrus and ovulation prior to 30 days postpartum. All of these cows showed several short, transitory increases in the level of progesterone in their milk lasting 1 to 2 days. For the 12 cows that exhibited estrus before 30 days after calving, these spikes of progesterone were observed about 5, 9, and 11 days after parturition. No progesterone was detected in the milk of the other 3 cows until 1 to 2 weeks before they showed estrus. With those cows, the ovaries remained very small during the early postpartum period until a few days before the first ovulation when the presence of ovarian follicles was detected.

In addition to the 15 cows that showed estrus prior to the first ovulation, 6 cows did not show estrus until the second postpartum ovulation. With these cows, ovulation did occur (as determined by palpation) and a functional *corpus luteum* resulted, as indicated by high levels of progesterone in the milk; but the cows showed no signs of estrus activity before the first ovulation. The second ovulation took place approximately 37 days postpartum. The interval between ovulations was normal; and at the second ovulation, estrus activity was noted.

Another 4 cows (14 percent of the animals used) displayed estrus behavior one or more times during the 55-day postpartum period, although the interval of 38 days to first estrus was longer than in the groups discussed previously. Following ovulation, there was little increase in the level of milk progesterone in these cows, indicating that luteal tissue in the *corpus luteum* was not formed or that it was functioning abnormally. The low level of progesterone detected undoubtedly would be too low to maintain pregnancy. Thus, if the cows had been inseminated, embryonic loss would have followed.

The remaining 3 cows from the total of 28 did not show any signs of cycling in the 55-day period and were considered to be anestrus. This group, which comprised 11 percent of the cows tested, appeared normal otherwise and cycled normally later in lactation.

When divided according to milk production, the cows with the highest daily milk yield (68.6 pounds per day) ovulated within the first 30 days, but the first ovulation was not accompanied by behavioral signs of estrus. These data suggest that silent heat is more common in the higher-producing cows than in others, perhaps resulting from stress caused by high milk production.

The Ka Mar tags and the androgenized heifer were ineffective in detecting signs of estrus in the group of high-producing cows. These cows did show detectable estrus activity in the subsequent estrous cycle. The second estrus period occurred within the 55-day postpartum interval.

The results indicate that within a 55-day period postpartum, most cows have at least one ovulation which is accompanied by a period of estrus activity. Supplemental detection devices, such as Ka Mar tags and an androgenized heifer, may be helpful in detecting such estrus periods, used in conjunction with visual observations.

Selecting Bulls by Multiple Traits

R.D. SHANKS

MANY FACTORS CONTRIBUTE to a strong breeding program for dairy cattle. The most important factor is bull selection. Other factors contributing to a good breeding program are cow selection and the mating design. Cow selection is discussed by another author. A suggested design would be to avoid mating a cow that is weak in one area to a bull also weak in the same area.

Several traits on bulls are available from the USDA and the breed associations. The traits discussed are predicted differences for milk (PDM), type (PDT), milk fat (PDF); also, milk-fat percentage (PD%) and the total performance index (TPI) of the Holstein breed. Semen prices were analyzed for 342 AI Holstein bulls from 7 AI organization supplying semen in the Midwest. The AI organizations included were the American Breeders Service, Carnation Genetics, Curtiss Breeding Service, Midwest Breeders Cooperative, Select Sires, Sire Power, and Tri-State.

The average characteristics of bulls for different price levels of semen are given in Table 1. Bulls with high semen prices have high values for TPI, PDM, PDT, and PDF. The genetically superior bulls have higher-priced semen than the others. Semen priced at $5 for 53 bulls averaged +1,015 PDM, -.06 PD%, and +27 PDF. Of the 53 bulls, 41 had a PDT that averaged +.60 for a TPI of +273. There were 38 bulls with semen prices of $10 to $12, all but 2 with type information, that averaged +380 TPI, +1,332 PDM, +.84 PDT, +39 PDF, and -.06 PD%. The milk-fat percentage remained constant as TPI, PDM, PDT, and PDF increased. The increase of $5 to $7 in semen prices was associated with a rise of 107 units for TPI, representing increases of 317 pounds of PDM, 0.24 unit of PDT, and 12 pounds of PDF. All 42 bulls with semen prices of $15 or more had information on both the conformation and milk production of their daughters. The 16 bulls with semen prices of $20 or $25 had increases of 93 units for TPI, 301 pounds of PDM, 0.20 unit of PDT, and 9 pounds of PDF compared to the average for the bulls listed at a semen price of $10 to $12.

As the semen price increased, concurrent increases in several traits were observed. The increase in TPI from 380 to 473 was of higher economic merit than the one from 273 to 380. An explanation is that sons from high-TPI bulls are of greater value than sons from low-TPI bulls. The sons of high-TPI bulls have the potential to be used heavily as service sires, but those of low TPI bulls do not have the same potential. Sales of female breeding stock from high-TPI bulls add other reasons for high semen prices for bulls with high TPI ratings.

The price level for semen and TPI are plotted in Figure 1. The solid line represents the average. The dashed lines are the maximum and minimum values in the TPI available at the given price for semen. All bulls in the highest price level had a greater TPI than any bull with semen priced at $5 or less. The bulls above the solid line are better-than-average semen buys for TPI. Those below the solid line for TPI need an extra, outstanding characteristic to justify the higher-than-average semen price. A high conception rate, calving ease, and upstanding daughters walking on sound feet and legs with snug udders are examples of extra, outstanding characteristics.

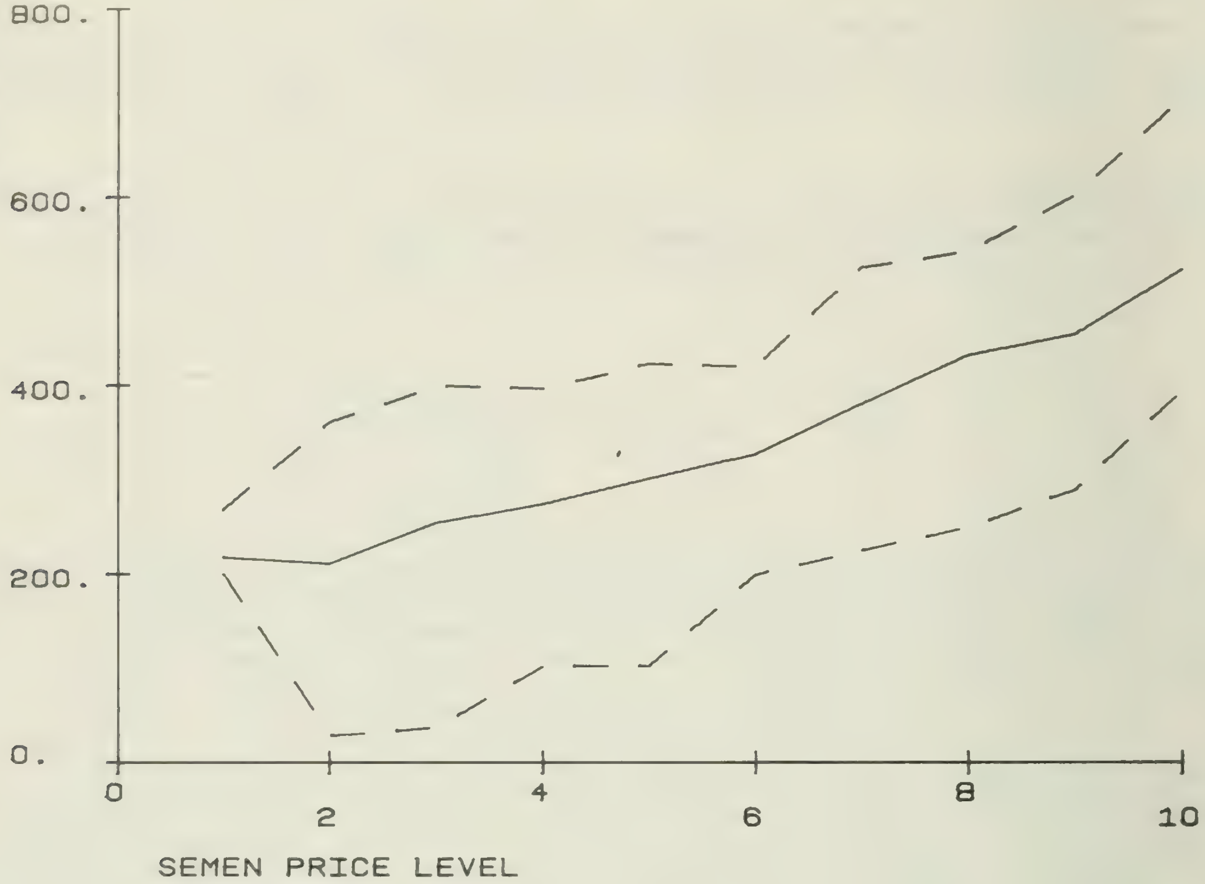


Figure 1. Minimum, maximum, and average TPI, by semen price level.

The trends indicated in Table 1 and the display given in the figure can be quantified as correlations in Table 2. The correlation between a trait and itself is 1.0. The TPI has the largest correlation with semen price of any of the traits analyzed. More than 20 percent of the differences in semen prices were caused by bulls with different TPI's. Semen price was positively correlated with TPI, PDM, PDT, and PDF. High semen prices were associated with high levels of TPI, PDM, PDT, and PDF.

As semen price increased, PDM increased but not as fast relatively as the increase in TPI because the correlation between semen price and TPI was larger than that between semen price and PDM. A plateauing of PDM was the trend at semen prices greater than or equal to $20. Bulls with a PDM greater than +1,500 were available in all except the $2.50 semen category. PDT was an important justification of semen prices at $15 or more. Bulls with a $15 semen price had a PDT of 0 or higher. Bulls with a PDT of more than +1.70 were available in all except the $2.50 semen category.

Changes in PD% between bulls were not associated with changes in semen price. The average PD% was almost constant at all semen prices. The range of PD% from +0.0 to -0.1 was encompassed in all price levels for semen.

Table 1. Average Characteristics of Bulls, by Semen Price Level

Level	Semen price	Number of bulls	TPI	PDM	PDT	PDF	PD%
1	$ 2.50	9	219	986	-.31	29	-.05
2	3 to 3.50	48	212	926	.28	21	-.08
3	4	62	270	1,071	.41	29	-.07
4	5	53	273	1,015	.60	27	-.06
5	6	53	300	1,072	.77	29	-.07
6	7 to 9	37	333	1,235	.68	34	-.07
7	10 to 14	38	380	1,332	.84	39	-.06
8	15 to 18	12	438	1,397	1.33	42	-.06
9	20 to 25	16	473	1,633	1.04	48	-.07
10	30 and over	14	535	1,669	1.83	48	-.08
Average	$10.12	342	319	1,149	.69	31	-.07

Table 2. Correlations between Semen Price, TPI, PDM, PDT, PDF, and PD%, Fall, 1980

	Price	TPI	PDM	PDT	PDF	PD%
Price	1.0	.46	.32	.30	.28	-.01
TPI		1.0	.69	.57	.78	.11
PDM			1.0	-.04	.46	-.45
PDT				1.0	.14	.17
PDF					1.0	.56
PD%						1.0

TPI was positively correlated with all other traits. TPI is truly a multi-trait selection criterion. High levels of TPI were associated with high levels of all other traits. TPI represents a 3:1:1 ratio of PDM, PD%, and PDT.

The following formula is used to calculate TPI: TPI = [3(PDM/560) + 1(PD%/.09) + 1(PDT/.70)]*50 where 560, 0.09, and 0.70 are the standard deviations of PDM, PD%, and PDT, respectively, and 50 is a multiplier factor used to obtain the desired numerical value.

The correlation between PDM and PDT was near zero, implying that almost all levels of PDT are available with all levels of PDM. There are bulls with high PDM's that also have high, medium, or low PDT's. PDM is positively correlated to PDF and negatively correlated to PD%. Bulls with a large PDM were associated with a large PDF and a small PD%.

A small positive correlation between PDT and both PDF and PD% was calculated. PDF was positively correlated with all other traits. Selection of bulls high in PDF would probably be associated with high levels of TPI, PDM, PDT, and PD%. PDF is also a multi-trait selection criterion. Less emphasis is placed on PDM and PDT and much more on PD% if selection is made on the basis of PDF rather than TPI. Approximate ratios of PDM, PD%, and PDT from selection for PDF are 8:20:1. A selection based on TPI represents a more complementary balance between PDM, PD%, and PDT than does one based on PDF.

Bull selection is not easy, but it is important. Decisions made today influence the genetic potential of the milking herd in 3 to 5 years.

Selecting Cows and Adjusting Records

R.D. SHANKS AND K.A. ROONEY

SELECTION IS THE WAY DAIRY CATTLE BREEDERS can influence the magnitude and direction of genetic progress. Most genetic progress will occur through sire selection. However, cow

selection cannot be ignored. The degree to which cow selection is possible depends on the management level of the herd. Maintaining a constant herd size coupled with a low reproduction rate limits the amount of culling possible, generally with 20 to 30 percent of a herd being replaced each year.

Replacing unprofitable, older cows with young cows is generally a wise decision, genetically and economically, because the younger cows are offspring of superior sires and will have lower health costs. Younger cows also usually have lower milk production because they have not yet reached their maximum.

In order to compare the cows on the same basis, the records need to be adjusted in order to predict the mature performance of the young cows. Also, cows freshening at different seasons of the year and during different stages of lactation need to be compared for genetic evaluation.

There are four ways to adjust a cow's lactation production in order to obtain a standard 305-day, 2X, ME record. If a cow is in milk less than 305 days, the record can be extended to 305 days so she can be compared properly to another cow with a 305-day record. The extension factors are slightly higher for younger animals calving at less than 36 months compared to animals calving after 36 months, regardless of lactation.

A rule-of-thumb for extending partial records is to double the production of a 2-year-old during her first 130 days to estimate her 305-day production. If a cow is older than 36 months at calving, double her 120-day production in order to estimate the 305-day figure. Younger animals tend to be more persistent. An adjustment to milking twice a day would be approximately 85 percent of the figure for milking three times a day during a complete 305-day lactation.

The third and fourth adjustments are for season and age at calving. Generally, production is higher for cows calving in the winter and lower for those calving during the summer. Additionally, age adjustments are slightly different for animals calving in different months of the year. The purpose of an age adjustment is to estimate a cow's production under the same environmental conditions, assuming that she was mature when she made the record. Age-adjusted records are identified as mature equivalent (ME). Adjusted fat percentages are calculated from the production figures for 305-day lactation, 2X for ME milk and fat production.

A moving average for herdmates is used to adjust for seasonal variations within a herd. A 3-month, moving-season average is used for large herds with 5 oremore animals freshening each month. The moving-season average includes the month of calving plus an equal number of months before and after the months of calving. For example, if a cow in a large herd calves in March, her herdmates are the cows calving in February, March, and April. Her performance will be evaluated by comparison with their averages for production. In smaller herds, cows calving in January and May would also be included, or as many additional months as needed in an attempt to accumulate at least 15 herdmates. The herdmate average may be calculated with a minimum of 5 herdmates during a maximum of 9 months.

Examples of adjusted records for 3 cows are given in Table 1. Two cows, Lollipop and Happy, calved in the same month. Happy has produced 510 more pounds of milk to date than Lollipop, but in 18 more days. Extending the records to 305 days, Lollipop is expected to outproduce Happy by 661 pounds. If both cows were mature, Lollipop would be expected to have an advantage of 936 pounds of milk. As a deviation from herdmates, Lollipop has an advantage of 1,004 pounds over Happy. Both Lollipop and Happy have a greater deviation from herdmates than Dafodil, although she is projected to out produce them by over 3,000 pounds of milk in 305 days. Older cows should outproduce young ones. The deviation from herdmates is a good approximation of a cow's genetic potential. All individual lactation records should be included in order to evaluate older cows accurately.

Table 1. Examples of Adjusted Records

	Month of calving	Calving age (yr., mo.)	Days in milk	Milk to date (lb.)	Projected 305-day output (lb.)	305-day ME (lb.)	Herdmate average (lb.)	Deviation from HM (lb.)
Lollipop	March	2/01	170	10,770	17,017	20,590	18,404	+2,186
Happy	March	2/02	188	11,280	16,356	19,627	18,445	+1,182
Dafodil	January	5/03	240	17,780	20,269	19,661	18,625	+1,036

Average Predicted Differences from Sire Summaries for Winter, 1979 Through Summer, 1980

M. GROSSMAN AND G.R. WIGGANS

THE AVERAGES OF PREDICTED DIFFERENCES (PD's) of bulls summarized in 1979 and 1980 point out the continued improvement in the average PD's of bulls in active artificial insemination (AI) service and emphasize the importance of using bulls with higher PD's each year.

For a long time, dairy producers have been advised to use bulls with the highest PD's they could afford in their breeding programs. Producers who wish to use above-average bulls in active AI service must keep increasing the level of service-sire PD's as the genetic level of the population improves. The PD's in the Sire Summaries are expressed in relation to a fixed genetic base established in 1974 from records on calving dates covering 1960 through 1974, with the average date of calving about 1968. Under this fixed base, the PD of the sire alone is not enough to determine whether a bull is above average. The PD of the average bull must be known, too.

Table 1 presents the average PD's for milk (PDM) in pounds, milk-fat percentage (PD%), fat (PDF) in pounds, and dollars (PD$) for bulls summarized in the winter and summer of 1979 and 1980, respectively, by breed. Except for the PD$, the PD's are comparable over the years. The PD$ is comparable only within years because different milk prices were used for each year's calculations. Economic weights were derived from the prices by computing the value of a pound of milk without fat and the differential value of a pound of fat. The value for fat reflects the value of its related components.

For the Sire Summaries covering Winter and Summer of 1979 (W79 and S79), the national average milk price used was $10.40 per hundredweight for milk having 3.5 percent fat. The differential was 12.8 cents for each change of 0.1 pound of fat per hundredweight of milk. This converts to an economic weight of $1.28 per pound of fat in the milk. The economic weight for milk without fat was:

$10.40 per hundredweight for milk minus (3.5 lb. fat/cwt. milk)($1.28/lb. fat) = $0.0592/lb. milk). Thus, for W79 and S79, PD$ = $0.0592 PDM + $1.28 PDF.

For the Sire Summaries covering Winter and Summer 1980 (W80 and S80), higher prices increased the economic weights; therefore, PD$ = $0.0653 PDM + $1.42 PDF. The increase in prices had little effect on the ranking of bulls by PD$ because the relative importance of PDM and PDF remained almost constant over the 2 years. For the 1979 summaries, the ratio of weights for PDF to PDM was 1.28/0.0592 = 21.62; for the 1980 summaries, the ratio was 1.42/0.0653 = 21.75.

For AI bulls designated as active after each summary, the average PDM and PDF for each breed increased since the W79 Sire Summary. For the first time, the average PDM in the Holstein and Jersey breeds exceeded +1,000. The average PD$ increased in 1979 (except for Brown Swiss and Milking Shorthorn) and again in the 1980 summaries. The average PD% changed only slightly, if at all, over the summaries.

Table 1. Average Predicted Difference (PD) for Milk (PDM) in Pounds, Milk Fat Percentage (PD%), Fat (PDF) in Pounds, and Dollars (PD$) for Bulls in Winter and Summer, 1979 (W79 and S79) and Winter and Summer, 1980 (W80 and S80), USDA-DHIA Sire Summaries, by Breed[a]

		Active AI bulls[b]					Non-AI bulls				
Breed	Summary	Number	PDM	PD%	PDF	PD$	Number	PDM	PD%	PDF	PD$
Ayrshire	W79	17	+534	-0.02	+19	+56	243	-20	+0.01	0	-1
	S79	20	+570	-.02	+20	+59	230	-26	+.01	0	-2
	W80	16	+568	-.03	+19	+64	244	+19	.00	+1	+3
	S80	17	+603	-.03	+21	+69	235	+17	.00	+1	+3
Guernsey	W79	42	+703	-.06	+27	+76	600	+21	-.01	0	+1
	S79	42	+749	-.07	+28	+80	613	+36	-.01	+1	+3
	W80	39	+727	-.06	+28	+87	570	+52	+.01	+3	+8
	S80	44	+785	-.08	+29	+92	543	+81	-.01	+3	+10
Holstein	W79	667	+880	-.07	+21	+79	6,734	-26	-.02	-4	-7
	S79	686	+928	-.06	+24	+86	7,913	+2	-.02	-3	-4
	W80	725	+977	-.06	+27	+102	7,188	+50	-.02	-1	+2
	S80	723	+1,040	-.06	+29	+109	7,718	+58	-.01	0	+4
Jersey	W79	94	+859	-.16	+28	+87	703	+138	-.04	+3	+12
	S79	86	+982	-.17	+33	+100	783	+204	-.05	+6	+20
	W80	89	+985	-.17	+33	+111	765	+210	-.05	+6	+22
	S80	90	+1,015	-.18	+34	+115	776	+273	-.06	+8	+29
Brown Swiss	W79	46	+788	-.05	+25	+79	267	+124	-.01	+4	+12
	S79	46	+782	-.05	+25	+78	301	+142	-.01	+4	+14
	W80	45	+803	-.06	+25	+83	256	+182	-.01	+6	+20
	S80	40	+911	-.06	+29	+101	274	+211	-.02	+6	+22
M. Shorthorn	W79	11	+865	+.02	+34	+95	148	+276	+.02	+12	+32
	S79	12	+794	+.02	+31	+87	78	+431	+.02	+18	+49
	W80	12	+903	+.02	+35	+109	93	+469	-.02	+18	+56
	S80	11	+985	+.02	+38	+118	97	+549	+.02	+22	+67
All breeds	W79	877	+857	-.06	+22	+79	8,695	0	-.01	-2	-3
	S79	892	+908	-.05	+25	+86	9,918	+27	-.02	-2	-1
	W80	926	+950	-.05	+27	+100	9,116	+71	-.02	0	+5
	S80	925	+1,011	-.05	+29	+108	9,643	+85	-.02	0	+6

[a]For W79 and S79, PD$ = $0.0592 PDM + $1.28 PDF; for W80 and S80, PD$ = $0.0653 + $1.42 PDF.
[b]Includes only bulls designated active after each summary.

For non-AI bulls, the average PDM and PDF increased for each breed since the W79 Sire Summary. The average PD$ went up in the 1979 and 1980 summaries, except for the Ayrshire breed. The average PD% changed only slightly, if at all, over the summaries.

The average PD's in Table 1 point out the importance of using AI bulls. In the Holstein breed, for example, the average PDM, PDF, and PD$ in the S80 Sire Summary for active AI bull exceeded those for non-AI bulls by 982 pounds of milk, 29 pounds of fat, and $105. For all breeds, the rates of improvement since winter 1979 in the averages for PDM, PDF, and PD$ were greater among active AI bulls than among non-AI bulls.

Dairy producers who use artificial insemination need to be especially alert to the opportunity provided by the increase in average PD's. In the Holstein breed, the average PDM has increased 160 pounds since the W79 Sire Summary and the average PDF, 8 pounds; the average PD$ increased by $7 in 1979 and again by $7 in 1980. Thus, dairy producers should raise their selection criteria by at least these amounts in order to continue using bulls of the same or greater relative superiority.

Microbiology of the Rumen and Other Anaerobic Ecosystems

R.B. HESPELL AND M.P. BRYANT

OUR RESEARCH EFFORTS IN MICROBIOLOGY cover a diverse range of topics, involving applied research as well as basic biological research. Some of the current areas include the survival of bacteria in the rumen, fermentation of methanol into fatty acids, effects of monensin on bacteria in the rumen, and enumeration and dirunal changes in carbohydrate-degrading bacteria in the rumen. Here, however, the discussion is limited to two other areas: nitrogen metabolism in ruminal bacteria and the methanogenic fermentation of cattle wastes.

NITROGEN METABOLISM

With dairy and beef cattle, a major goal is maximizing the synthesis of volatile fatty acids and microbial cells from feedstuffs within the rumen, while minimizing inputs. To achieve that goal, feeding programs usually are designed to provide a balance of all dietary components. This is particularly important for plant carbohydrates and nitrogenous compounds such as urea.

Part of the microbial basis for balancing the two dietary components stems from the fact that maximum microbial growth occurs only when the rates of energy utilization produced from microbial degradation of carbohydrates are matched to the rates at which the nitrogen compounds needed for the biosynthesis of cell material are made available. Ammonia is of special significance since it provides 40 to 70 percent of the total microbial nitrogen.

Little is known about the intracellular enzymes involved in assimilating ammonia into the microbial cell-pool intermediates and material. Furthermore, we do not know how these enzymes may vary when the levels of ammonia in the rumen or carbohydrate energy sources are limiting or when microbial growth rates vary.

Two intracellular enzymes in many bacteria used for ammonia assimilation are the energy-requiring glutamine synthetase (GS) and the nonenergy glutamate dehydrogenase (GDH). Some animal studies have shown that ammonia can be fixed mainly into amides (protein compounds) with the extensive use of glutamine synthetase. However, from simple theoretical calculations, the exclusive use of energy-requiring GS instead of GDH by bacteria in the rumen would require an energy expenditure of some 16 to 22 percent of the total energy needed to form the entire cell mass, reducing cell yields by an equivalent amount. Such an energy expenditure for ammonia assimilation is unrealistic, suggesting that both enzymes must be used to varying extents depending on the prevailing conditions in the rumen.

To gain an understanding of this enzyme interplay and how it may vary according to changes in growth rates, the energy available due to the formation of fermentation products, or both, we are studying *Selenomonas ruminantium* grown in glucose-limited and ammonia-limited continuous cultures. Some of our preliminary findings follow.

The organism was grown at dilution rates (D) of 5, 10, 20, and 30 percent per hour, which are equivalent to 1.2, 2.4, 4.8, and 9.6 turnovers per day in the rumen. Using glucose-limited cultures with ample concentrations of ammonia, the cell yields and GDH activity increased until D = 0.2, then subsided. With increasing D, the activities of lactate-acid dehydrogenase, urease, and GS increased along with formation of lactate and succinate; but that of acetate and propionate decreased. With ammonia-limited cultures that had ample concentrations of glucose, the GS and urease activities were very high regardless of D; and the fermentation pattern shifted toward a greater production of lactate.

These data suggest that both the microbial growth rate and the route of ammonia assimilation significantly affect the yields of microbial cells and the patterns of fermentation acids. When ample fermentable carbohydrate and ammonia levels are present in the rumen (such as shortly after feeding), optimum growth of the microbial cells occurs. However, if ammonia is limiting, more lactate is produced and cell yields decrease. This is the result of increased GS activity and lower energy yields from fermentation. If fermentable carbohydrate is limiting, more acetate and propionate are made to maximize energy formation and cell yields are low due to slow growth rates. However, cell yields can decrease even more if ammonia levels are low enough to produce higher GS activity and lower GDH activity.

All of these changes can vary greatly, depending on the specific growth rate that occurs when either ammonia or carbohydrate are limiting. Overall, the interactions in the rumen between fermentable carbohydrates, ammonia levels, microbial growth rate, and microbial cell formation are quite complex. Much more research with the microorganisms and their enzymes is needed in order to expand our knowledge so that this information can be used to plan rational approaches for balancing feedstuffs that will produce the maximum conditions for fermentation in the rumen.

FERMENTATION OF CATTLE WASTES

Anaerobic bacterial fermentations of animal wastes are becoming important because of their importance in producing methane as an alternate energy source and the use of the residual fermentation materials as possible feed supplements or as fertilizers. A series of experiments has been conducted to determine the kinetics of acetate, propionate, and butyrate degradation (the breakdown products of carbohydrate digestion) and their contribution (along with carbon dioxide reduction) to methanogenesis (the production of methane). The rates of these reactions were estimated by infusion of radioactive compounds into stirred benchtop fermentors fed on a semicontinuous basis with cattle wastes. The fermentations were carried out at 105° and 140° F., temperatures which are considered near optimum for mesophilic digestion (95° to 113° F., or normal) and thermophilic digestion (above 122° F.), respectively.

The data from these experiments indicated that acetate was the major precursor of the methane produced. In the mesophilic digestor, the contribution of the methyl group of acetate to methanogenesis was 75 percent shortly after feeding the digestors, but declined to 72 percent by 13 to 14 hours afterward. Corresponding values in the thermophilic digestor were 5 to 10 percent higher.

Other results showed that propionate accounted for 13 and 17 percent of the methane produced in the mesophilic and thermophilic digestors, respectively. Butyrate accounted for 7 to 9 percent of the methane produced in either of the digestors. Bacteria capable of oxidizing either propionate or butyrate were present in both digestors, indicating that these fatty acids are degraded to methanogenic substrates such as acetate, hydrogen gas, and carbon dioxide. About 24 to 29 percent and 19 to 27 percent of the methane produced came from reductions of carbon dioxide in the mesophilic and thermophilic digestors, respectively. The reduction rate was lowest shortly after feeding the digestors, gradually increasing thereafter. A small amount of the carbon dioxide produced was converted into acetate, accounting for 1.4 to 5.3 percent of the acetate created in the digestor.

Overall, the results show that the kinetics for the methanogenic fermentation of cattle wastes are quite similar to those for anaerobic digestion in other systems, such as municipal sludge; also, that acetate is the major compound converted into methane. Since methane production was highest between 1 to 6 hours after feeding the digestor, doing that oftener than once a day (as was done in these studies) may lead to greater methane production, depending on the levels of degradable organic matter in the cattle wastes and the turnover times of the material in the fermentor.

The thermophilic methane production was 18 percent higher in the thermophilic digestor than in the mesophilic one. The difference was greater when shorter retention times were used and more organic matter was fed, producing more methane. The practical application of small-scale fermention systems compatible with on-farm useage needs further development.

The Feeding Value of Wet Brewer's Grains for Lactating Dairy Cows, A Preliminary Report

D.A. GRENAWALT, C.L. DAVIS, AND G.C. McCOY

MOST OF THE INFORMATION AVAILABLE ABOUT THE FEEDING VALUE of brewer's grains as well as distiller's grains for dairy cattle was obtained by using the dried products. Little is known about the feeding value of wet brewer's grains, especially concerning the maximum amounts that can be used in the ration of lactating dairy cows.

Previous studies indicated that 20 percent of the total dry matter of the diet could be supplied from wet brewer's grains (a product with 80 percent moisture) with good success. In fact, at that level, the wet brewer's grains appeared to be equal to or superior in feeding value to the dried brewer's grains for lactating cows.

This report provides preliminary data on the response of lactating dairy cows receiving wet (pressed) brewer's grains in the ration at four different levels. The diets fed are given in Table 1.

Table 1. Wet Brewer's Grains, Experimental Diets, Four Levels

Ingredient	Diet A	B	C	D
	percent of total dry matter			
Corn silage	40	40	40	40
Grain mixture	60	40	30	20
Wet brewer's grains	0	20	30	40

The diets were equalized on basis of digestible energy (3.0 to 3.05 megacalories per pound of dry matter), crude protein (15.2 percent), calcium (0.53 percent), and phosphorus (0.42 percent). The ration components (corn silage, grain mixture, and wet brewer's grains) were mixed together at feeding time and were fed twice a day.

Table 2 contains preliminary data on milk production and the intake of dry matter.

Table 2. Daily Milk Production and Dry-Matter Intake, Experimental Diets with Four Levels of Wet Brewer's Grains

	Diet, by percent of wet brewer's grain 0(A)	20(B)	30(C)	40(D)
Mean daily milk yield (lb.)	56.3	55.1	53.7	49.0
Mean daily intake of dry matter (lb.)	43.3	40.2	37.8	32.6
Efficiency: pounds of milk per pound of dry matter	1.30	1.37	1.42	1.50

These data have not been subjected to statistical analysis. Obviously, however, when wet brewer's grains are incorporated into the diet to supply 40 percent of the total dry matter, milk production suffered because of the inability of the cow to eat as much dry matter as with the other diets. Until further analyses of the data are completed, it seems safe to say that lactating dairy cows respond favorably to rations with 20 to 25 percent wet brewer's grains (dry-matter basis).

Thus, the main decisions about using wet brewer's grains are the: (1) cost per unit of protein, compared to other sources; (2) consistent availability of the product; and (3) ease with which the product can be incorporated into the feeding program. NOTE: The uniformity of the product used in this experiment, as well as its keeping quality (1-week storage), were excellent.

The Effect of Dietary-Protein Solubility on the Lactation Performance of Dairy Cows

R.R. GRUMMER AND J.H. CLARK

DURING THE PAST 25 YEARS, the average milk production per cow has approximately doubled. To facilitate such an increase, greater quantities of nutrients must be absorbed from the animal's digestive tract, delivered to the mammary gland, and used consequently for milk synthesis.

The objective of recent research at the University of Illinois has been to determine whether milk production and milk composition could be affected by feeding soybean meal exposed to varying levels of heat treatment as a protein supplement. Work in our laboratory has shown

that the chemical properties of soybean protein are changed during heat treatment so that the protein becomes less soluble and less degradable by rumen bacteria than before. Thus, feeding soybean supplements exposed to heat treatment should allow more soybean protein to escape degradation in the rumen and to pass into the small intestine of the animal where it is absorbed. If enough nutrients are present in the rumen for normal microbial growth, greater total protein (bacterial protein plus feed protein) also should be available to the small intestine for digestion, absorption, and utilization.

Twenty-six lactating Holstein cows were used in a 20-week trial to determine the effect of the solubility of dietary protein on lactation performance. Two weeks after calving, the cows were assigned to 1 of 5 diets that varied only in terms of the protein solubility (leve of heat treatment) of the soybean supplements.

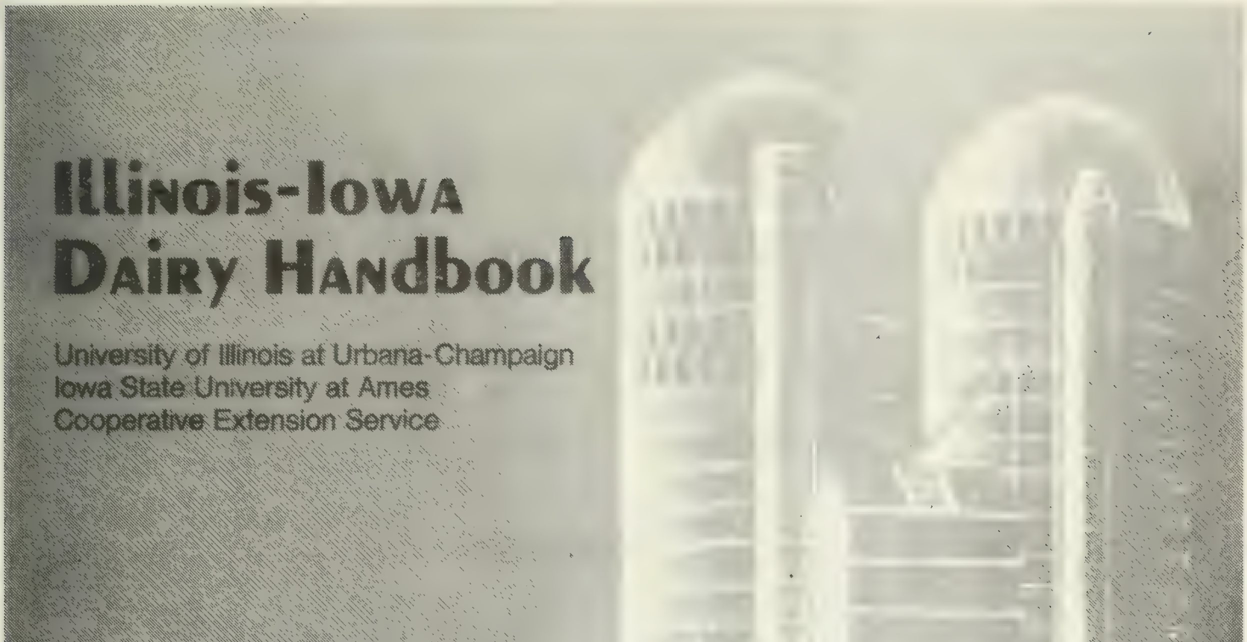
The supplements used and their corresponding protein solubility (percent of total protein) were: (1) soybean meal, 18.1; (2) soyflake W, 10.2; (3) soyflake X, 17.9; (4) soyflake Y, 38.0; and (5) soyflake Z, 51.1. The diets contained 13-percent crude protein and consisted on a dry-matter basis of ground corn (51 percent), corn silage (29 percent), alfalfa-grass hay (12 percent), and the assigned protein supplement (8 percent). The measures used were: overall milk production; the 4-percent, fat-corrected milk yield; the milk-fat percentage; and the milk-protein percentage. These did not differ significantly among the 5 treatment groups (Table 1). Feed intake was similar among the 5 groups, and the apparent digestibilit of the 5 diets did not differ significantly.

The results from this study indicate that reducing the protein solubility of rations for dairy cattle by heat-treating soybean protein supplements does not alter lactation performance when the rations contain 13-percent crude protein.

Table 1. Average Daily Intake of Dry Matter, Milk Yield, and Milk Composition by Dairy Cows Fed Diets Varying in Protein Solubility

	Treatments				
	Soybean meal	Soyflake S	Soyflake X	Soyflake Y	Soyflake Z
Soybean protein solubility (%)[a] . . .	18.1	10.2	17.9	38.0	51.1
Total-ration protein solubility (%)[a]	24.6	21.7	23.9	30.7	34.4
Dry-matter intake (lb./day)	40.9	42.7	42.0	41.8	40.7
Milk yield (lb./day) . .	72.4	67.8	74.1	72.6	66.2
4% FCM yield (lb./day)[b]	64.9	60.1	59.4	61.8	58.7
Milk protein (%)	3.2	3.3	3.2	3.3	3.2
Milk fat (%)	3.4	3.2	2.9	3.2	3.1
TDN (%)[c]	68.3	69.9	68.4	68.2	66.9

[a]Percent of total protein. [b]FCM (fat-correct milk). [c]TDN (total digestible nutrients).


Illinois-Iowa
Dairy Handbook
University of Illinois at Urbana-Champaign
Iowa State University at Ames
Cooperative Extension Service

Illinois-Iowa Dairy Handbook

Two major challenges dairy producers face are keeping up with the latest information and practices in the dairy industry plus finding general guidelines and recommendations. To assist you, dairy specialists from Illinois and Iowa have developed the Illinois-Iowa Dairy Handbook. This new handbook will be available at area dairy days on a subscription basis. Materials are contained in specifically designed two-inch, three-ring notebook in five general categories. Below is a list of materials that will be in the five sections this year

Management

1. A planning guide for dairy operations.
2. Using computers on the dairy farm.
3. Managing dry cows.

Feeding

1. Using buffers.
2. Feeding high-moisture corn.
3. Protein feeding strategies.

Milking and Mastitis

1. Interpreting somatic cell counts.
2. Using automatic detachers.
3. Planning aids and layouts for dairy parlors—trigon, polygon, and rotary—as well as side-opening and herringbone ones.

Breeding

1. Prostaglandins.
2. Genetic tools
3. Genetic improvement trends.
4. Reproduction management.
5. Heat detection.
6. Progesterone.
7. Sire-summary interpretation.

General

1. Hoard's Dairyman Calf Care Bulletin.
2. Illinois-Iowa 1981 Revised Feeding Guide.
3. Midwest Plan Service Dairy Housing and Equipment Handbook.
4. North-Central Guidelines for Analyzing Milking Systems.

Additional guide sheets will be developed and mailed to update and expand the handbook. The cost of the Handbook will be $10 to $15, which includes an additional 6 to 8 guidesheets. Thus, the purchase of the Handbook includes approximately 2 years of guidesheets and other materials. After that, additional items for the Handbook will be available at cost. Dairy producers, agribusiness personnel, educators, and others who may be interested are invited to subscribe.

ILLINOIS
DAIRY DIGEST
FACTS FOR LAND OF LINCOLN DAIRYMEN

Volume 8, Number 4 *October, 1979*

Colostrum, Milk, or Replacer for Your Calves

Several products can be fed to young calves. The factors to consider are nutrient values, digestibility, availability, convenience, and cost. Below is a ranking of calf feeds.

1. Fresh or frozen colostrum.
2. Soured colostrum.
3. Whole milk.
4. Top-quality milk replacer.
5. Poor-quality milk replacer.
6. Overdiluted colostrum.

The first four products are acceptable. Fresh or frozen colostrum ranks first because of its high nutrient content. Souring colostrum results in some protein degradation and potential feed refusals. The following table compares the nutrient values of various feeds on a liquid basis (as used for feed).

	First Colostrum	Pooled Colostrum[a/]	Whole Milk	Milk Replacer[b/]
	percent			
Dry matter	28.3	16.0	12.1	12.0
Fat	6.0	5.5	3.5	2.3
Protein	18.8	5.5	3.3	2.7

a/ First six milkings, Holsteins cows.
b/ One part replacer (24 percent protein-20 percent fat) & 7 parts water.

Colostrum (soured, fresh, or frozen) exceeds the value of whole milk and milk replacers for nutrient content and quality. Calf raisers must use colostrum, especially with young calves which need high-quality digestible feed. Whole milk has a higher nutrient content than milk replacer. Economics usually favors using a milk replacer.

1 pound replacer + 7 pounds water = 8 pounds of milk.

1 pound of replacer is worth 40 cents.

8 pounds of milk is worth 88 cents.

The feed value of milk replacers vary. Check the feed tag to see how your replacer measures up:

- 20 percent protein (derived from milk products).
  22 to 24 percent protein (when chemically modified, soy proteins are used).
- 10 to 20 percent fat.
- 0.5 percent fiber, or less.

Look at the ingredients on the tag and compare the list below:

Optimum	Acceptable	Inferior
Skim milk powder	Soy isolates	Meat solubles
Buttermilk powder	Soy concentrates	Fish protein concentrates
Dried whole whey	Chemically modified soy protein	Distillers' dried solubles
Delactosed whey		Brewer's dried yeast
Casein		Oat flour
Milk albumin		Wheat flour

The Illinois Dairy Digest Newsletter

The *Illinois Dairy Digest* provides the latest research information available from the University of Illinois and other sources. In addition, practical timely tips to help dairy producers make management decisions are included plus announcements of statewide educational events of interest to the dairy industry. The subscription for 1981 is $4 for 4 issues. Make your check payable to the: University of Illinois Agricultural Newsletter Service. Return to:

Agricultural Newsletter Service
Cooperative Extension Service
116 Mumford Hall
Urbana, IL 61801

Look over the list of other newsletters available from the University given on the next page. To subscribe, just check the additional newsletters you would like to receive and send in the form with your check attached. Remember that subscription charges are tax-deductible.

FARM ECONOMICS FACTS AND OPINIONS: Economic principles applied to farm problems such as pricing strategy, crop production costs and market outlook. Issued monthly.

WEEKLY OUTLOOK: Anticipates reports and interprets current market information—supply, demand and price outlook—for agricultural products. Issued weekly except for the last two weeks of December.

OUTLOOK UPDATE: Four issues each on corn, soybeans, cattle and hogs, timed to coincide with inventory reports for each commodity. An in-depth look—extensive statistical tables, current forecasts, price-forecasting methods, forecasts of prices and price changes, evaluation of forecasts. Also includes discussions of pricing strategies. Sixteen issues per year.

AGRONOMY NEWS: Provides timely information on crops and soils. Ten issues per year.

ILLINOIS IRRIGATION NEWSLETTER: Presents information on new irrigation techniques and equipment; some in-depth treatment of specific topics of interest to irrigators. Ten issues per year.

BEES AND HONEY: Timely tips on bees, honey production and management. Ten issues per year (none in July or August).

SWINE REPORT: Current information on swine feeding, breeding, management and engineering. Issued quarterly.

BEEF REPORT: Current information on beef feeding, breeding, management and engineering. Issued quarterly.

SHEEP REPORT: Timely management suggestions and educational activities. Six issues per year.

MONTHLY POULTRY SUGGESTIONS: Latest information on management, marketing, business and regulatory developments in the poultry industry. For hatcherymen, commercial poultrymen, small flock owners and poultry servicemen. Six issues per year.

INSECT, WEED AND PLANT DISEASE SURVEY BULLETIN: Weekly reports on situation and recommendations for control of insects, weeds and plant diseases. Issued weekly April-August; 20 issues per year.

HOME, YARD AND GARDEN PEST NEWSLETTER: Insect, weed and plant disease pests of the home and garden. Current controls, application equipment and methods, storage and disposal of pesticides, plus other topics. Weekly April-July; biweekly in August. Twenty issues per year.

SPRAY SERVICE REPORT: Provides information on commercial fruit culture, insect and disease problems and recommended control measures. Issued weekly March-May; biweekly June-August; special issues September-February. Eighteen issues per year.

ILLINOIS DAIRY DIGEST: Provides the latest dairy research information available from the U of I and other sources; practical, timely tips to help dairymen make management decisions; announcements of educational events. Four issues per year.

ILLINOIS NURSERY NOTES: Nursery news and timely tips for commercial nurserymen and landscape contractors. Four issues per year.

ILLINOIS DAIRY DIGEST

FACTS FOR LAND OF LINCOLN DAIRYMEN

November 1, 1980

Dear Subscriber:

To keep ILLINOIS DAIRY DIGEST coming to your door during 1981, tear off the order form at the bottom of this sheet, make any corrections needed in your mailing label on the back, and return the form and your check for $4.00 today.

If you subscribe to more than one newsletter from the University of Illinois Agricultural Newsletter Service, you will be billed for each one separately. You can, however, write one check to cover the cost of renewing them all. But please return the address panel from each notice with your check.

If this is the only newsletter that you now receive, we invite you to take a look at the others available and to subscribe at this time. All of the newsletters available from the University of Illinois Agricultural Newsletter Service are described on the back of this sheet. To subscribe, just check the additional newsletter or newsletters you'd like to receive on the form below and add the subscription cost to your renewal check. Be sure to check out the special *combination offers* for some newsletters. And remember that your subscription charge is tax-deductible.

Sincerely,

T. Roy Bogle

T. Roy Bogle
Assistant Director, Cooperative Extension Service

COOPERATIVE EXTENSION SERVICE
UNIVERSITY OF ILLINOIS
AGRICULTURAL NEWSLETTER SERVICE

(Return this panel with your check)

__Farm Economics Facts and Opinions	$ 6.00	$____
__Weekly Outlook	15.00	____
__Outlook Update	20.00	____
Weekly Outlook & Outlook Update, both for	25.00	____
__Agronomy News	4.50	____
__Illinois Irrigation Newsletter	6.00	____
Agronomy News & Irrigation Newsletter, both for	10.00	____
__Bees and Honey	4.50	____
__Swine Report	3.50	____
__Beef Report	3.50	____
__Sheep Report	5.00	____
__Monthly Poultry Suggestions	3.50	____
__Insect, Weed and Plant Disease Survey Bulletin	8.50	____
__Home, Yard and Garden Pest Newsletter	8.50	____
Insect, Weed & Plant Disease Bulletin & Home, Yard and Garden Newsletter, both for	15.00	____
__Spray Service Report	7.50	____
__Illinois Dairy Digest	4.00	[illegible]
__Illinois Nursery Notes	5.50	____
TOTAL		____

Return to:
University of Illinois
Ag Newsletter Service
Cooperative Extension Service
116 Mumford Hall
Urbana, Illinois 61801

Make check payable to:
University of Illinois
Agricultural Newsletter Service

STATE · COUNTY · LOCAL GROUPS · U.S. DEPARTMENT OF AGRICULTURE COOPERATING
THE ILLINOIS COOPERATIVE EXTENSION SERVICE PROVIDES EQUAL OPPORTUNITIES IN PROGRAMS AND EMPLOYMENT

1982
Illinois Dairy Report

Department of Dairy Science
Cooperative Extension Service
Agricultural Experiment Station
College of Agriculture
University of Illinois at Urbana-Champaign

Meeting the '82 Challenge

Jar

Dep

MAR

JIM

CAR

RAN
m

BAR
a

K.R
P

CHA
r

MIC
D

ROB
T

MIC
E

EDW
m

RAL
E

DAN
a

1982 Illinois Dairy Days

January 11 Kankakee, Redwood Inn

12 Marengo, Cloven Hoof Restaurant

13 Freeport, Masonic Temple

13 Elizabeth, Community Building

14 Sterling, Emerald Hill Country Club

January 15 Peoria, Heritage House

19 Quincy, County Farm Bureau Building

20 Breese, American Legion Hall

21 Effingham, Extension Center

Authors

Department of Dairy Science, University of Illinois at Urbana-Champaign, except as noted

MARVIN P. BRYANT, professor, microbiology

JIMMY H. CLARK, professor, nutrition

CARL L. DAVIS, professor, nutrition

RANJIT S. FERNANDO, research assistant, management

BARBARA SHARAK-GENTHNER, research assistant, microbiology

W.R. (REG) GOMES, professor, reproductive physiology and department head

CHARLES N. GRAVES, associate professor, reproductive physiology

MICHAEL GROSSMAN, associate professor, breeding and genetics

ROBERT B. HESPELL, associate professor, microbiology

MICHAEL F. HUTJENS, professor, Extension dairyman

EDWARD H. JASTER, assistant professor, management

RALPH V. JOHNSON, associate professor, Extension dairyman

JANE A.Z. LEEDLE, former research assistant, microbiology

J. ROBERT LODGE, professor, reproductive physiology

GENE C. McCOY, associate dairy scientist, management

RAUL MACHADO, former research assistant, physiology

BRIAN J. MILLER, research assistant, reproductive physiology

HOYLE B. PUCKETT, professor, agricultural engineering

SUWAT RATTANARONCHART, research assistant, breeding and genetics

JAMES L. ROBINSON, associate professor, biochemistry

KATHLEEN A. ROONEY, research assistant, breeding and genetics

ROGER D. SHANKS, assistant professor, breeding and genetics

ALBERT L. SMITH, former research assistant, reproductive physiology

SIDNEY L. SPAHR, associate professor, management

Contents

1982 THEME: MEETING THE '82 CHALLENGE

UNIVERSITY OF ILLINOIS RESEARCH REPORTS

The Department of Dairy Science

W.R. (REG) GOMES

We in the Department of Dairy Science are pleased to present the 1982 Illinois Dairy Report, our third report of Dairy Day activities and summary of research in the department. The Dairy Report and our other statewide educational programs and publications are designed to provide the Illinois dairy industry with useful information on the latest developments in dairy research and production. This report, the *Illinois-Iowa Dairy Handbook*, the *Illinois Dairy Digest*, and the *Illinois Dairy Herd Improver* outline many facets of our research and extension programs at the University of Illinois. In addition, the department offers a comprehensive teaching program in dairy science fields that leads either to a four-year degree or advanced graduate degrees.

During the summer of 1981, we were proud to host many of you at our open house, which was held in Urbana on our dairy research farm. Our new polygon milking parlor, heifer facilities, and feeding facilities (which feature highly automated feeding, milking, and record-keeping equipment) have given us capabilities in teaching and research that are unsurpassed in the U.S. We welcome you and your families to visit with us, see our facilities, and discuss our programs.

As a newcomer to the state of Illinois, I have been gratified by the warm welcome extended to my family and me by the University community and the dairy industry of the state. I have enjoyed working with the faculty members of the department (listed below), the herd manager Gene McCoy, and the industry advisory committee to the department. The committee members for 1981-82 are Carl Baumann of Highland, Myron Erdman of Chenoa, Ray Hess of Hampshire, William Lenschow of Sycamore, Kevin Lyons of Granville, Roger Marcoot of Greenville, Melvin Schweizer of Nokamis, and Richard Vetter of Arlington Heights.

The faculty of the department, the members of the advisory committee, and I welcome your comments, suggestions, and questions. We appreciate your interest in the 1982 Dairy Day program and hope that you will find it valuable.

DEPARTMENT OF DAIRY SCIENCE

Faculty members	Specialization
Marvin P. Bryant, professor	Ruminant microbiology
Jimmy H. Clark, professor	Dairy cattle nutrition
Carl L. Davis, professor	Dairy cattle nutrition
Charles N. Graves, associate professor	Reproductive physiology
W.R. (Reg) Gomes, professor and department head	Reproductive physiology
Michael Grossman, associate professor	Dairy breeding and genetics
Gerhard W. Harpestad, associate professor	Extension dairyman
Robert B. Hespell, associate professor	Ruminant microbiology
Michael F. Hutjens, professor	Extension dairyman
Edwin H. Jaster, assistant professor	Dairy cattle management
Ralph V. Johnson, associate professor	Extension dairyman
Bruce L. Larson, professor	Biochemistry and lactation
J. Robert Lodge, professor	Reproductive physiology
Michael R. Murphy, assistant professor	Dairy cattle nutrition
James L. Robinson, associate professor	Biochemistry
Roger D. Shanks, assistant professor	Dairy breeding and genetics
Sidney L. Spahr, associate professor	Dairy cattle management

Opportunities for Genetic Improvement

RALPH V. JOHNSON

Cattle breeders are always concerned about the next generation of animals in the herd. Their goal is to make genetic progress by the wise choice of parents for each new generation of herd replacements. Their success depends upon how effectively they use the information available about the transmitting ability of the parents.

Although one must consider the transmitting ability of both dams and sires, the greatest progress in genetic improvement can be expected from an intensive program of sire selection. This is true because there are more opportunities to select sires than dams. It has been estimated that with artificial insemination (AI), we can select the best one of every 100 bulls available. On the other hand, under optimum conditions only the best 70 of every 100 cows can be selected to produce the next calf crop. About 75 percent of the potential genetic improvement in dairy cattle can be achieved through sire selection.

GOALS FOR A BREEDING PROGRAM

To develop an effective sire selection program that will result in the most rapid genetic improvement, follow these steps.

1. Set goals for the traits to be included in the breeding program. The levels of predicted difference (PD) for production of milk and fat, type traits, or both should be at or above average for the breed.
2. Select bulls with the highest PD for the traits included in the breeding program. Apply the standards to the entire group of bulls selected at any one time rather than to each bull. The strengths and weaknesses of the bulls will offset each other. The group of bulls will meet the goals established for the herd, even though not every bull will have a high PD for each desirable trait.

Maintaining a high level of milk production per cow is one of the most important keys to profit. Using bulls with the highest PD for milk is the best method for making genetic progress in production. USDA researchers have found that for every 100-pound increase in a sire's PD milk the production of his daughters increased an average of 96 pounds. Selection of sires can be based on traits other than milk production, but doing so decreases the progress made in improving any trait.

GOOD MANAGEMENT PRACTICES

Records available through the Dairy Herd Improvement program are the cornerstone for genetic improvement. These records give the performance of each animal and management aids such as reproductive status of the herd, culling recommendations, and other herd summaries.

Reducing losses from death of calves and keeping infertility problems to a minimum will increase both genetic progress and the potential for profit. If you are successful in dealing with these problems, more genetically superior animals will be available as herd replacements, and you can practice more intensive culling to remove cows with low production or serious type defects.

Breed all heifers to dairy bulls. The use of beef bulls on first-calf heifers will reduce the number of replacement heifers available each year by 30 percent or more. The result is a major loss in genetic progress.

Keep the calving interval for the herd as close to 12 months as possible. For each month the interval is extended beyond 12 months, there is an 8 percent reduction in the number of calves born in the herd each year.

Now is the time to plan a breeding program. The decisions you make today about sire selection will largely determine what the herd will be like during 1985-89. The genetic ability of the replacement heifers entering the herd in 1985 will be determined by the matings made in 1982.

THE ADVANTAGES OF USING AI BULLS

The average PDs for AI and non-AI bulls are shown in Table 1. The PDs for AI bulls averaged 962 pounds of milk, 31 pounds of fat, and 115 dollars more than for non-AI bulls.

Table 1. Average Predicted Differences for AI and Non-AI Bulls

Type of bull	Average predicted differences Milk, pounds	Fat, pounds	Dollars
AI	+1,111	+33	+128
Non-AI . . .	+ 149	+ 2	+ 13

The average PDs for bulls are increasing with each sire summary. If you want to improve your herd, you need to use genetically superior bulls. During the past year the average PD milk of AI bulls has increased about 120 pounds. Your goal should be at least that much higher than a year ago.

The average PD milk of natural service (non-AI) bulls has also increased during the past year but at a much lower rate. This means that if you are not using the top bulls available through AI the production of your herd is not likely to keep up with the rest of the dairy industry.

The average predicted differences for various breeds of active AI bulls (summarized in July, 1981) are shown in Table 2. Use these data as a guide when you select bulls for your herd.

Table 2. Average Predicted Differences for Bulls in Active AI Service, July, 1981

Breed	Number of bulls	Predicted difference milk, pounds	Predicted difference test, percent	Predicted difference fat, pounds	Predicted difference dollars
Ayrshire	17	+711	-.05	-23	+85
Guernsey	45	+873	-.10	+31	+109
Holstein	730	+1,145	-.06	+33	+131
Jersey	85	+1,159	-.20	+39	+141
Brown Swiss	48	+934	-.04	+32	+115
Milking Shorthorn	13	+970	+.03	+39	+128
Red and White	1	+277	+.10	+24	+58
All breeds	939	+1,111	-.05	+33	+128

Predicted difference dollars is a measure of the PD for milk and for fat at current market prices. It is the best production trait for most dairy farmers to use in ranking bulls because it most closely reflects changes in the milk check.

COW EVALUATION

Cow evaluation and selection has an important role in herd improvement. A cow's ability to produce is determined by her genetic ability and the environmental conditions that affect all of her records. Here are some commonly used measures of a cow's productive ability:

1. *Estimated Producing Ability (EPA).* This is the best estimate of a cow's ability to produce either more or less than her herdmates. It is not a very precise estimate of her genetic merit.
2. *Estimated Average Transmitting Ability (EATA).* This is a genetic evaluation of a cow's ability to transmit production to her off-spring. It combines her own records with those of her dam, her paternal and maternal sisters, and her daughters.
3. *USDA-DHIA Cow Index.* This is the most widely used estimate of transmitting ability. It is based upon the cow's production (expressed as a deviation from the production of herdmates), on the PD of her sire, and on the Cow Index of her dam. If the dam's Cow Index is not available, the PD of the dam's sire (maternal grandsire) is used in calculating a cow's index.

SELECTING BULLS TO IMPROVE TYPE

Each dairy farmer must consider his or her own situation in deciding if it will be profitable to emphasize selection of bulls on the basis of their ability to improve type. You must sell breeding stock at a profit to take advantage of improved type.

A recent study at Virginia Polytechnic Institute, in which data were collected from 35,000 Holstein cows, showed that improved type causes little improvement in lifetime production, production during a lactation, or length of time in the herd. The study did show, however, that udder traits are more important than nonudder traits in selecting for type. These traits were udder support, sound fore and rear udders, and correct teat placement. Only a small percentage of differences among cows in lifetime performance are due to differences in their type.

Dairy producers should give some attention to type traits in addition to, but not in place of, predicted differences for production traits. Selection of bulls on the basis of predicted difference type is nearly always the most efficient method of improving type unles the goal is to improve one type trait only.

Most of the benefit of corrective mating seems to be achieved by avoiding matings between sires and dams with the same weaknesses in type traits.

Continually evaluate your sire selection program to be sure that it is being followed. Standards must be changed to keep up with the genetic ability of the entire dairy cattle population. Dairy producers can lose the greatest opportunity for genetic improvement avail able to them if they do not subject their programs to constant evaluation.

Reproduction in the High-Producing Dairy Herd

W.R. (REG) GOMES

During the lifetime of most dairy producers, annual milk production per cow has increased 240 percent. At the same time, the number of dairy farms has decreased to one-fourth its former level. Those two trends have led to larger, higher-producing, dairy herds than ever before.

This increase in milk production has come about largely because of artificial insemination in dairy cattle, which has made the present population of cows genetically superior to that of only a few years ago. In addition, we have fed our cows better, managed them better and pushed them to the limits of their genetic capabilities. The benefits of higher production, however, have been accompanied by an increase in the incidence of certain health problems in recent years. And the burden of management is greater than ever before.

Reproductive inefficiency is one of the most costly and production-limiting health problems the dairy industry faces today. One-fifth of all direct health costs on the dairy farm is related to reproductive failure. Another fifth is expended on semen, much of which is "wasted" in repeat breeding animals. Reproductive failure accounts for the loss of more cows from the herd than any other factor except low production.

DO HIGH-PRODUCING COWS HAVE MORE REPRODUCTIVE PROBLEMS?

Researchers in Iowa have noted that animals in high-producing herds have lower conception rates, more days open, and increased calving intervals. Records collected by the Dairy Herd Improvement Association (DHIA) in the Midwest also indicate that calving interval has increased among member herds as milk production has increased. On the other hand, studies conducted in Israel, on herds producing 17,500 to 21,500 pounds of milk, do not confirm this trend. Nor do studies done in North Carolina and Oregon.

Whether or not increased levels of production are the actual cause of increases in reproductive problems, it seems obvious that greater herd size usually forces the producer to spend less time with each cow. And when less time is spent with each cow, the result is

usually reduced fertility. Data now being collected show that cows being fed finely ground, high-grain diets may be losing some of their reproductive capacity.

It is probably not worthwhile to try to determine whether high production or altered herd management is to blame for reproductive failure. Instead, we should develop management techniques that will allow us to improve reproduction in the outstanding cows we have developed. We can apply the same techniques to cows that are not record-breakers.

HOW CAN WE IMPROVE HERD REPRODUCTION?

Most work during the last 10 to 15 years has shown that improvement of reproductive management is needed in three or four areas. These include heat detection, insemination procedures, pregnancy diagnosis, and herd reproductive health. In each of these areas, several new techniques are being investigated. We should not forget the old techniques however.

HEAT DETECTION

The single most important problem that has faced dairy producers since the introduction of artificial insemination is heat detection. The ability to detect estrus is essential for successful artificial insemination in cattle. As herds grow, so does the problem of heat detection. Most of the "Jim-Dandy Heat Detectors" on the market have not solved the problem.

So, what should we do? First, we have to understand that the problem is not so much with the cow as with the dairy manager. Although "silent heats" do occur on occasion, most cows show regular, observable heats from about 40 days after calving until they are pregnant. Unfortunately, many of these heat periods are never seen by the herd manager. In a study conducted at the University of Maryland, 68 percent of the heat periods occurring in a group of Holsteins were observed by the herd manager. Researchers in Canada monitored cows continuously for 80 days by means of closed circuit TV cameras and noted that 94 and 100 percent of the cows showed signs of heat before their second and third ovulations after calving. However, herd managers observed only 44 and 64 percent of those heats. Other data show that up to 30 percent of cows reported to be in heat are not in heat.

How can we improve this poor record? First, the observer must know what to look for. Hired personnel and other helpers on the farm may not know the signs of heat. A cow is in heat when she stands to be mounted. Cows in heat may mount other animals, but so will cows that are not in heat. Cows in heat are frequently nervous, produce a mucous discharge from the reproductive tract, or show signs that they have been mounted. A minor bloody discharge on or under the tail is usually a sign that the cow was in heat 2 to 3 days earlier.

Once the signs of heat are well known, the observer must know when and where to look. As shown in Table 1, more cows come into heat during the evening and night. It is necessary, at the very least, to set aside a time early in the morning and another in the evening for observation of heat. For maximum results a third period should be added (Table 2). Each period should last no less than 30 minutes. Observe the animals in an area where they can move around, footing is good, and there are few distractions (do not schedule estrus detection at feeding time).

Table 1. Time of Day When Estrus Was First Detected in Dairy Cows

First detection of estrus	Percentage of cows observed: Canada	Percentage of cows observed: New York
6 pm to midnight	34	..
Midnight to 6 am	22	..
6 am to noon	23	..
Noon to 6 pm	21	..
Dusk to dawn	56	73
Dawn to dusk	44	27

AIDS IN HEAT DETECTION

The most important aids in accurate detection and recording of heat are the simplest. Proper identification of the animal is a must. Numbers should be visible at a reasonable distance. Good reproductive records tell you which cows you can expect to be in heat. Although all cows should be observed, those cows should receive special attention. Give your full attention to heat detection during the observation period; allow no other task to interfere.

Table 2. Effect of Observation Frequency and Heat Detection Aids on Efficiency of Heat Detection

	Percentage detected	Accuracy, percent
Casual observation	35	..
Twice daily observation	68	93
Continuous observation	89	..
Marker bull (twice daily for 1 hour) . . .	87	..
Tail chalking and observation	82	..
Mount detectors	69	29
Mount detectors and observation	83	..
Pedometer activity	68 to 74	83
Pedometer and observation	93	..

Source: Data adapted New York, Maryland, North Carolina, and California publications.

After perfecting your observation procedures and techniques, you may also try heat detection aids to improve your efficiency. As shown in Table 2, mount detections, tail chalking, marker bulls (or masculinized females), and pedometers can help in heat detection when used in conjunction with good observation. Trained dogs have been used experimentally to detect heat in cows; and changes in body temperature, cervical mucus, and animal activity have been recorded electronically. But these techniques are not available to the average dairy manager.

TIME OF BREEDING

For some 45 years dairy producers have been told that cows first seen in heat in the morning should be bred the same afternoon and that cows in which estrus is first detected in the afternoon should be bred the next morning. Assuming that the producer detects heat accurately and has a flexible breeding schedule (on-farm inseminator), that advice is still good. Data from New York and Virginia suggest, however, that cows can be inseminated at one time in the day (all cows are bred that are first seen in heat after the previous day's inseminations) without a significant drop in conception rate.

INSEMINATION OF COWS

Sperm cells in insemination straws are extremely fragile. Since they cannot stand temperature fluctuations during storage, the nitrogen level should be checked frequently, and canes should be raised out of the tank as little as possible.

Thawing procedures should be noted and carefully followed for each insemination. Insemination procedures should be performed carefully and properly controlled. The differences between trained inseminators (and the differences can be great) usually have more to do with care and use of proper, standardized procedures than with skill.

PREGNANCY DIAGNOSIS

Any reproductive management program should include routine examinations for pregnancy. Milk progesterone assays are an early indicator of pregnancy and aid in determining the reproductive status of problem cows. Most cows are routinely examined for pregnancy, using rectal palpation, by a qualified veterinarian. When a cow is determined to be pregnant, she should still be observed for heat in case she suffers pregnancy loss. All cows that have been diagnosed as pregnant but still show heat should be reexamined since some pregnant cows come into heat.

A number of studies are under way, both in the U.S. and overseas, to develop rapid, accurate pregnancy tests that can be used during the first 15 to 30 days of gestation. Although these studies are clarifying important principles, a breakthrough in this area is not likely to occur soon.

HERD HEALTH

Consistent results from research and on-farm experience have shown that a comprehensive herd health program carried out with the full cooperation of a progressive dairy farmer and a knowledgeable large-animal veterinarian returns more dollars in savings than are ever spent on service. This program includes complete records on each animal, a vaccination program, routine uterine examinations of cows about 30 days postpartum, and pregnancy diagnosis near the second missed estrus after insemination.

By performing a routine examination, the veterinarian is able to identify obvious problems and recommend specific treatments. These treatments should be followed by regular examinations to ensure that the problem is corrected. In addition to the regular examinations and routine diagnoses, provision must be made for emergency care of health problems and for handling cows that remain problem breeders long beyond a "normal" time.

WHAT ABOUT PROBLEM COWS?

A good herd health program, which includes accurate heat detection and concerned management, should eliminate most reproductive problems that are not physiological. Moreover, routine postpartum examinations of the reproductive tracts and careful monitoring of good records should alert the dairy producer and veterinarian to minor physiological problems that can be treated before they become major.

After these steps are taken, a few animals will still not reproduce with the regularity expected of them. Some will have cystic ovaries, some will not show heat, and some will appear normal in every way except that they do not become pregnant. In all those cases, some response to various treatments can be expected. But the manager must sooner or later decide that some of the animals are not worth the effort and should be culled.

WHAT ABOUT FEEDING AND REPRODUCTION?

Although several studies indicate that diet and reproduction are related in dairy cattle, a realistic appraisal of the results of those studies suggests that no drastic changes in the way we feed our cows are warranted. Data from several research laboratories indicate that dairy cows will not conceive well if they are in the peak of lactation and are rapidly losing weight. Other scientists disagree. But all agree that we should feed high producing cows as well as possible.

As long as dairy cattle are fed enough for milk production and maintenance, their energy and protein level seem to have little effect on reproduction. Extreme deficiencies of phosphorus, vitamin A, or other nutrients can influence reproduction, but there is no evidence that adding those nutrients at an above-normal rate is of any value. Reports from Germany, however, indicate that adding beta-carotene to the diet of dairy cattle improves reproduction in dairy cattle. Comparable studies done in Israel fail to confirm this conclusion.

Research done in Ohio about five years ago showed that selenium, when added to the diet of dry cows or injected with vitamin E, prevented four out of five cases of retained placenta in herds that had a high incidence of the disease. Little doubt remains that this treatment is effective when selenium is deficient in the ration. But adding selenium to a diet that is not deficient in the mineral is not beneficial.

WHAT NEW TECHNIQUES ARE AVAILABLE?

Superovulation and embryo transfer have become readily available in the cattle industry. The potential benefits of these techniques are great, but the skill and expense they require severely limit their use. Studies are in progress that may make possible embryo storage by freezing, embryo sexing, production of clones, or even genetic engineering of cattle.

Prostaglandin-F_2 alpha has been approved for use in synchronizing estrous cycles in dairy heifers. This technique may increase the ability of many dairy producers to use artificial insemination in their heifer herds.

Routine treatment of dairy cattle with hormones (GnRH) has been shown by Missouri workers to improve reproduction in postpartum dairy cattle. Whether this treatment will become available and prove profitable for an entire herd remains to be seen.

Sexing of semen into male and female-producing cells has been a dream of reproductive physiologists for more than fifty years. Although some successes have been reported, it has not been demonstrated that the procedure can be repeated. Until it is shown to be successful consistently, it will remain a dream.

The ABCs of Minerals: Availability, Balance, and Costs

MICHAEL F. HUTJENS

A properly balanced ration provides enough mineral as well as energy, protein, and vitamins. Mineral shortages or excesses can cause metabolic diseases, reduced milk yield, reproductive problems, and poor feed utilization. Remember these three key words in setting up your mineral program:

Availability—the net amount of mineral the animal can use for production

Balance—the amount in grams of each mineral relative to the animal's needs and to other minerals in the diet

Cost—the price per unit of mineral fed

Another consideration is the mineral feeding system, which is the method of delivering minerals to the animal.

BIOLOGICAL AVAILABILITY

Before a nutrient in a feedstuff can be used, it must be digested, absorbed, and transported to where it will be used. Biological availability is a measure of the element's ability to support some physiological process. Although availability does not influence the animal's true need, it may change the needed level of a particular mineral in the ration. Factors that influence availability include age, chemical form, level and form of other elements and nutrients, animal health, homeostatic and hormonal control, type of diet, and chelating agents.

Calcium availability began to attract renewed attention when Kansas researchers reported that calcium in alfalfa can be less than 40 percent available. The National Research Council (NRC) has set calcium availability at 45 percent. Calcium supplements are estimated to be 65 percent available. Generally, most rations based on NRC standards are adequate.

The percentage of phosphorus available in various supplement sources is listed in Table 1. The NRC has based its phosphorus requirement for milk production on 55 percent availability to the animal. If your mineral supplement consists of ingredients equal to or better than bone meal, cost per unit of phosphorus should be the main factor in your selection of a phosphorus source.

The availability of trace and macro minerals in supplement sources varies. Generally, the mineral availability of sulfate and carbonate salt forms is acceptable. It is lower in some oxide forms. However, these guidelines do not hold for all minerals. Purchase feed from a reputable company because its nutritionists will use sources in which a high percentage of mineral is available. It is difficult to judge the quality of feed from the tag alone.

Table 1. Relative Biological Availability of Phosphorus From Various Sources

Source	Relative availability, percent
Beta tricalcium phosphate . . .	100
Monosodium phosphate	115 to 125
Monoammonium phosphate	115 to 125
Mono-dicalcium phosphate . . .	100 to 115
Dicalcium phosphate	100
Sodium tripolyphosphate	100
Bone meal	90 to 100
Rock phosphate, low fluorine .	50 to 70
Rock phosphate, soft	25 to 35

MINERAL REQUIREMENTS

The mineral requirements (expressed on a dry matter basis) for the total ration are listed in Table 2. These values are from the 1978 NRC tables.

Table 2. Mineral Nutrient Requirement for Lactating Dairy Cows

Macro minerals	Minimum percentage	Maximum percentage	Micro minerals	Minimum, ppm[b]	Maximum, ppm[b]
Calcium[a]	0.60	..	Iron	50.0	1,000
Phosphorus[a] . . .	0.40	..	Cobalt	0.1	10
Magnesium	0.20	..	Copper	10.0	80
Potassium	0.80	..	Manganese	40.0	1,000
Sodium	0.18	..	Zinc	40.0	500
Sodium chloride .	0.46	5.0	Iodine	0.5	50
Sulfur	0.20	0.35	Molybdenum	..	6
			Fluorine	..	30
			Selenium	0.1	5

[a]The requirement for these minerals increases with milk production.
[b]1 percent = 10,000 ppm.

Calcium and phosphorus are key minerals for lactating and dry cows. In lactating cows the recommended amount in grams of each mineral is based on body weight, milk yield, and fat test. If legume is the main dietary source of calcium, increase the requirement by 25 percent or adjust the level of calcium in the forage down by 40 percent. For example, if a cow needs 80 grams of calcium, feed it 100 grams. If your alfalfa contains 5 grams per pound, use 3 grams per pound of alfalfa in balancing the ration. For dry cows the correct level of calcium and phosphorus is more important than the ratio. Large-breed cows should receive less than 100 grams of calcium per day and 35 to 40 grams of phosphorus. Small-breed cows require 65 to 70 grams of calcium and 25 to 30 grams of phosphorus.

Potassium and magnesium needs are usually met by ruminant rations if legumes are fed or if soybean meal is the source of protein supplement. With high grain feeding, forage programs based on corn silage, or abnormally low feed levels, rations may have to be supplemented with additional potassium or magnesium.

Sulfur occurs mainly with organic compounds in the body, especially with amino acids such as methionine and cysteine. Dietary sulfur is used by rumen bacteria to synthesize amino acids and vitamins. The nitrogen-to-sulfur ratio in the total ration should be 10:1 for optimal nitrogen retention and microbial growth in the total diet. Excessive levels of sulfur lower feed intake and milk yield.

Salt (sodium and chloride) has received renewed attention because of excessive force feeding and soil buildup caused by heavy manure application. One ounce of salt for maintenance plus 1 ounce for each additional 30 pounds of milk is adequate. Adding sodium bicarbonate (buffer) or monosodium phosphate can meet sodium requirements but not chlorine needs. Salt can also trigger or increase the degree of udder edema in dry cows and heifers. Any source of salt (sodium or potassium, for example) can cause edema problems.

Trace minerals found in trace mineralized salt are copper, zinc, iodine, manganese, iron, and cobalt. These minerals should be added routinely to rations in Illinois. Iodine levels in milk have increased dramatically in recent years. Producers must feed minimal amounts (10 to 15 milligrams) of iodine per day, and avoid excessive levels. Listed in Table 3 are guidelines against which to check your feed tags. One source of iodine is adequate.

Table 3. Iodine Levels in Typical Supplements Used in the Midwest

Supplement type	Iodine level, percent	Amount needed to supply 10 mg of iodine, lb/cow/day
Protein	0.00014	16.6
Protein	0.0004	5.6
Protein	0.0007	3.1
Mineral	0.01	0.22
Mineral	0.025	0.09
Mineral	0.085	0.03

Selenium recommendations remain variable. According to soil tests, most of Illinois (the eastern two-thirds of the state) is marginal to deficient in selenium. Adding 2 to 3 milligrams per cow per day to rations could reduce the incidence of retained placenta and improve the health of

the dairy herd. High levels can be toxic, so be sure you add the correct amount. Injectible sources of selenium and vitamin E are commercially available for calves and dry cows. Inject dry cows 20 days prepartum and calves at birth according to the directions on the label.

COSTS

Consider the cost per unit of nutrient when selecting mineral supplements. Consider only the nutrients that are needed to meet nutritional requirements. Be sure to compare the costs of commercial supplements to the costs of the raw ingredients of those supplements (Table 4).

Table 4. Costs of Various Mineral Supplements

Mineral	Calcium, percent	Phosphorus, percent	Cost per 100 pounds	Cost per pound of calcium	Cost per pound of phosphorus
Dicalcium phosphate	21	18	15.50	0.74	0.86
Supreme 17:17	17	17	21.00	1.24	1.24
Zinger 1:1	12	12	18.00	1.50	1.50
Limestone	36	0	3.00	0.08	..
Lo-high mineral	0	18	27.00	..	1.50
High phosphate	0	15	18.00	..	1.20
Monoammonium phosphate	0	24	24.00	..	1.00

Keep in mind that commercial supplements may cost more because they may contain other needed minerals or vitamins and because the manufacturer provides such services as packaging, formulation, forage testing, and mixing.

MINERAL FEEDING SYSTEMS

Force feeding is the recommended method of feeding mineral to dairy cows. This method solves the problems of palatability difference, variation in feed consumption from day to day and among cows, and overconsumption (also called "luxury consumption"). It allows the dairy manager to determine the amount of various mineral supplements needed according to levels of mineral in forage and grain and according to milk production requirements. If you adopt this system, keep in mind that requirement tables are intended as guidelines. In addition, be sure that you select the correct mineral supplement and add it in the correct amount. You may make a mistake if you use a rule of thumb such as 1 percent dicalcium phosphate and 1 percent trace mineralized salt.

The best method of force feeding mineral is to use a complete ration system. Each bite contains the correct mineral balance. The second best method is to use grain as a carrier (especially for calcium, phosphorus, or both) since grain intake increases with milk production. The least satisfactory carrier is forage because intake decreases as production increases (grain dry matter replaces forage dry matter).

Topdressing is commonly practiced in stanchion barns. Cows are fed 1 to 3 ounces of a trace mineralized salt and 2 to 6 ounces of a calcium-phosphorus supplement. The minerals are either fed separately or mixed in a set proportion. Topdressing allows the cow to receive extra nutrients before it has consumed the maximum amount of dry matter. Some dairy managers have reported that topdressing 1 to 2 ounces of a high-phosphorus mineral plus the normal ration improves reproductive performance.

Cafeteria feeding, the newest approach in the Midwest, is a form of free-choice feeding in which cows usually receive 4 to 10 minerals. Two types of cafeteria systems are commercially available; one uses single-element minerals (limestone, monosodium phosphate, elemental sulfur, or benonite, for example), and the other offers a complex mineral line (there are 20 to 50 ingredients per mineral package, and 6 to 15 supplements are available). The system depends on the animal's ability to "know" what it needs. During a 19-month trial in Minnesota, no significant difference in milk production or fat test was observed between groups. Reproductive performance and metabolic blood profiles were also similar. It cost less to feed the control group (2 cents per cow per day) than the cafeteria group (3.8 cents per cow per day).

Free choice is a common method of providing minerals. Animals may choose a feed for any of several reasons:

True appetite—A physiological need is expressed as an instinctive desire for a given nutrient.

Learned appetite—The animal "learns" that a given choice results in a feeling of well-being.

Simple preference—The animal's choice has no relation to nutritional value, but is based upon flavor, odor, moisture content, acidity, or particle size.

Research has clearly shown that animals can select mineral for its salt content. Early research also suggested that they experience phosphorus craving (evidenced by the chewing of bones), but the results of recent research do not support that conclusion. After conducting a series of studies, researchers in New York expressed doubt that free choice feeding of minerals to dairy cows is economical or feasible. Cows that were fed balanced rations consumed 45 percent more than their calcium requirement and 53 percent more than their phosphorus requirement. When cows were fed rations deficient in calcium and phosphorus, they did not consume enough mineral to meet the requirements or correct the deficiencies. A satisfactory approach is to force feed an optimal level of mineral and provide cows with trace-mineral salt and a calcium-phosphorus supplement through free-choice feeding when grain intake does not deliver the desired amounts of these minerals.

OTHER TOPICS RELATED TO MINERAL FEEDING

Chelation is a mineral that is organically bound in a ring-type structure (most mineral supplements are inorganic). Some common chelating agents are amino acids and polysaccharides. If the chelate complex is water soluble, it is referred to as "sequestered." Care should be exercised with chelates for these reasons:

1. No research has been done showing that chelates improve the performance of dairy cattle.
2. Since chelated minerals are more available to the animal, it should be fed smaller amounts of those minerals.
3. As one mineral is released from the organic molecule, another mineral can move in and become tied up, resulting in an imbalance or deficiency.
4. The cost of chelates can be two to five times higher than that of inorganic forms.

Metabolic blood profiling is the chemical analysis of blood to detect impending production diseases and imbalances. Researchers in Minnesota, Virginia, and England have reported that blood values vary with the season, the stage of lactation, and among different herds. The test can detect abnormal blood values, identify the cows that have abnormal blood values, and show relationships between blood value and milk yield. Although the blood profile gives us insight into potential problems, the results are not a sufficient basis for solutions or recommendations.

Hair analysis is another way of assessing mineral status in cattle. Research results indicate that the accuracy of the analysis varies widely for a number of reasons:

1. The test results vary with the season.
2. Excessive amounts of several key minerals, such as calcium and phosphorus, are not reflected in hair.
3. The length of hair is not uniform.
4. Black hair is higher in several key elements than white hair.
5. New growth and shedding hair are not suitable for analysis.
6. Thorough washing of hair in hot water is not sufficient; it must be extracted with ether.
7. Hair can be contaminated by the paper containers in which it is collected.

We do not recommend this method of evaluating mineral status or planning a mineral mixture.

Mineral additives are compounds that perform functions in addition to contributing mineral ions. Sodium bicarbonate or magnesium oxide (which acts as a buffer), sodium benonite (which affects the rate of passage), and calcium carbonate (a lower-gut buffer) are examples of mineral additives. When they are needed, feed them in adequate amounts, but control the total level of mineral in the ration. Total mineral levels above 5 percent in the grain mixture may lower feed intake and palatability.

Is There a Computer in Your Future?

SIDNEY L. SPAHR

Since so many new applications are being found for high technology, it is only natural that some of it should find a place in agriculture, specifically in the dairy industry. Many prominent people in the dairy industry today think that microcomputers and electronically controlled equipment will have a major effect on farming techniques in the 1980s. There are tremendous opportunities for application of computer technology in the dairy industry.

Many repetitive, tedius, menial tasks are performed daily on the dairy farm, and the dairy manager must gather much information about individual cows to make management decisions efficiently. Computer technology could reduce much of this labor and provide the manager with more information on which to base decisions. Although dairying has been and will probably continue to be labor-intensive, electronic equipment could make our work much easier and enable us to make better, more timely decisions.

WHAT CAN COMPUTERS DO?

Most dairy producers associate computers with the analysis of records. Dairy producers have become familiar with this use of the computer through the Dairy Herd Improvement program. Many have used computer-based programs for balancing rations and know that breed associations use computers in the preparation of pedigrees. Computer technology can also be applied in dozens of ways to the analysis of farm management records. For example, a farm's cash flow situation can be improved through income and expense projections and simulations. Computerized tax records, inventories of supplies, and many other types of information in farm management can be handled easily by small computers.

The application that seems most attractive to dairy producers today, however, is not the analysis of records. Producers are excited about the idea that we can control equipment and record and monitor events automatically, thereby gaining more complete control over and records of what is happening to individual cows throughout the day (Figure 1).

Electronic identification of cattle is the key requirement for automatic, daily recording of information. Illinois researchers have been working with identification systems for several years. At least four commercial systems are on the market (Delaval, Germania, Tesa, and Dairytronics). They electronically identify individual cows and have a microprocessor-controller that automatically feeds grain to individual cows housed in groups. The advantages of these systems are obvious to dairy producers who have switched from stanchion barns to group housing of animals. These systems enable the producer to continue feeding cows individually even though they are housed in groups. The manager can control the amount of feed that is dispensed to each cow. In addition, the recording device has a counter, enabling a micro-processor to record the amount of feed dispensed to each cow. Thus, if a cow goes off feed or does not consume her feed for some reason, the manager knows it and can give her special attention.

The automatic milk-machine detacher is another example of the use of a small computer to control equipment. A sensing device, which determines when milk flow stops, serves as a switch to activate the shutoff of vacuum and the retraction of the claw unit for removal. To prevent premature removal of the units the detacher can be made to pause between the time low milk flow is detected and the time the vacuum is shut off. Milking continues for another 30 seconds after milk flow actually reaches the cut-off point. The milker unit comes off in a consistant manner at every milking relative to the end of milk flow, regardless of who is operating the milking machine.

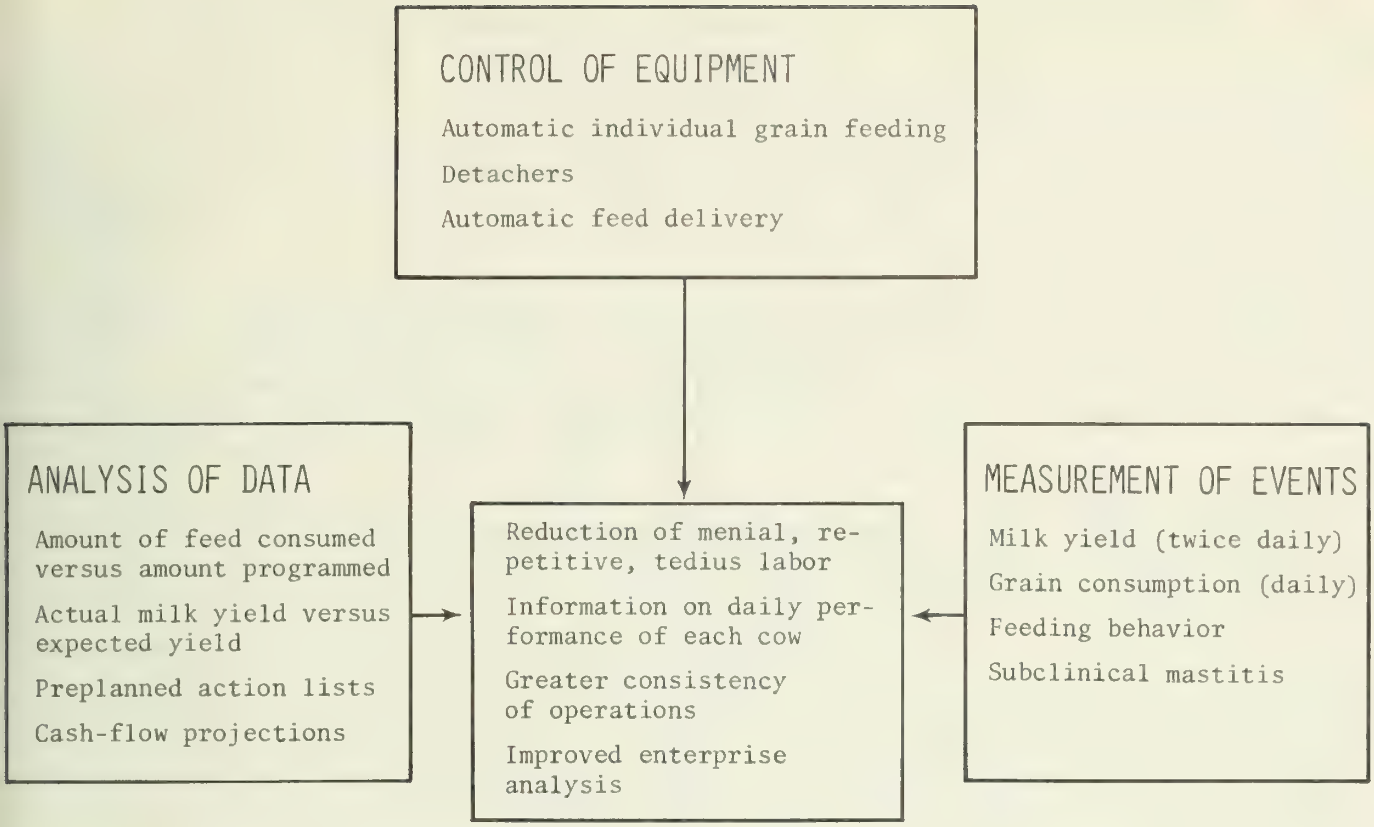


Figure 1. Application of computers and automation on dairy farms.

Many people think that the most beneficial application of electronics on the dairy farm will be in the milking parlor. It is now possible to have the milk from each cow measured at each milking and the yield automatically recorded. A system that combines electronic identification with milk yield measurement is expected to be on the market this calendar year. Automatic monitoring for subclinical mastitis at every milking will also be possible before long. Dairy producers are able to improve their management greatly when they can measure and record the amount of grain each cow consumes and the amount of milk she produces. To accomplish this task is the greatest challenge facing dairy producers in the management of parlor milking and group feeding. The new electronic tools will allow dairy managers to do a much better job of managing cows individually even when they are housed, fed, and milked in groups.

WHAT EQUIPMENT IS AVAILABLE?

Electronic equipment and computers come in various styles and differ in complexity. Data analysis, future planning, tax records, and payrolls can be done on many of the units now available for on-farm use. The models available include Apple, Radio Shack, Pet, Cromemco, and many others. These models, termed microcomputers, are desk-top units and are very versatile. Although they are small, they can do as much as the large computers of ten or fifteen years ago. They consist of a central processing unit, a visual display unit (such as the CRT, or cathode ray tube, which looks like a television screen), a keyboard for entering information, a printer that produces hard copy of the results, and some type of unit for storage of programs and data (Figure 2). The most common type of storage unit is the floppy disc. Data may also be stored in a preprogrammed cube of instructions supplied by the manufacturer. To store a large amount of information, you may need a hard disc. Other means of storage are magnetic tapes in cassettes or reels. Listed on page 14 are some common computer terms and their definitions.

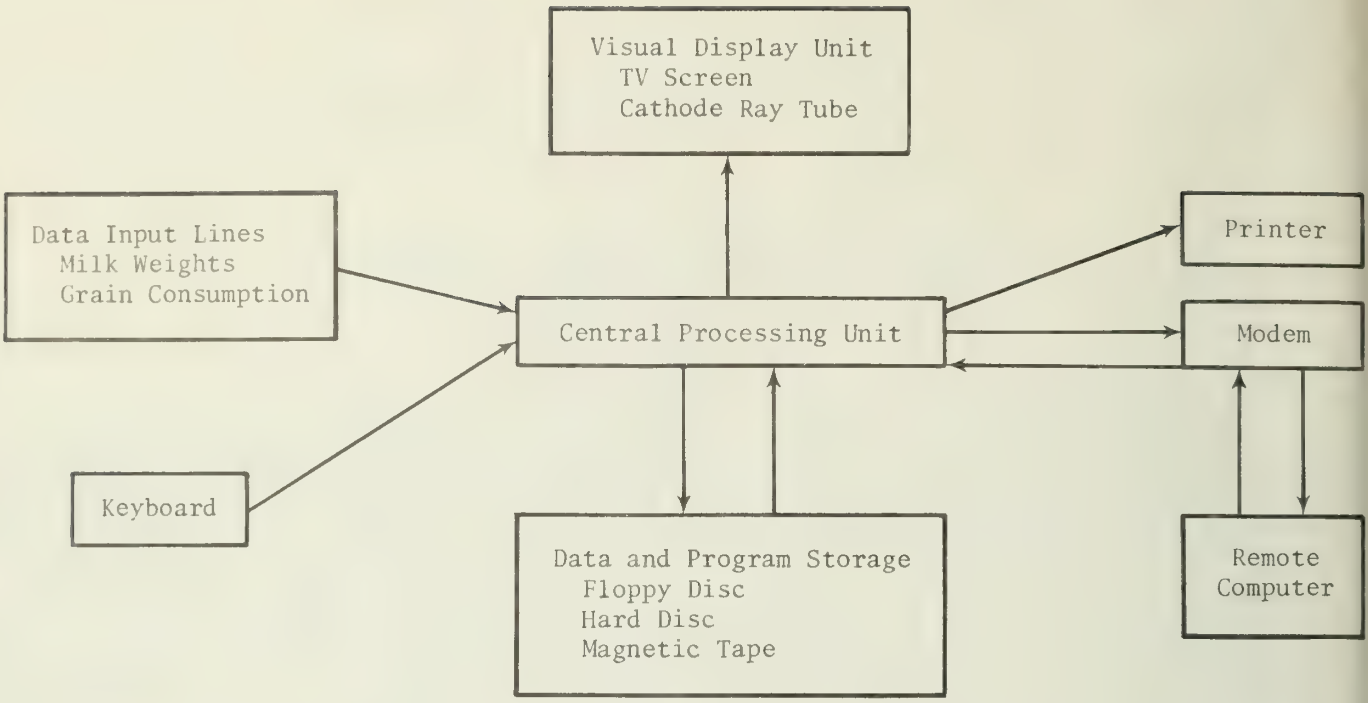


Figure 2. The components of a computer system.

Common Computer Terms

Central processing unit (CPU)	Coordinates and controls the system. Contains RAM storage and usually some ROM operating instructions. The keyboard and CRT are often a part of the CPU's cabinet.
Floppy disc	Disc on which programs and data are stored.
Kilobyte (K)	A block of 1,024 memory locations (bytes) for storage of numbers or characters on a CPU or floppy disc.
Random access memory (RAM)	The amount of memory available in the central processing unit for temporary storage of programs, data, and results.
Read only memory (ROM)	Permanent instructions for operation that can be changed only through system rebuilding.
Baud	Rate of transmission of data. Common baud rates are 300 and 1,200.
Microprocessor	An electronic controller that has been permanently programmed at the factory for a specific, repetitive function.
Microcomputer	A small computer (2-96K) that can be programmed by the user or controlled by prewritten programs on floppy disc.
Software	A set of instructions that control what the computer does.

You can use a microcomputer, such as Apple, as a stand-alone unit for analysis. In that case you will probably have to invest a substantial amount of money in prewritten programs, each of which costs several hundred dollars. The advantage of this approach is that all your records are private. You can obtain programs that are tailored to the specific needs of your farm; you have none of the problems associated with long-distance telephone calls and time sharing; and you do not have to worry about the computer shutting off just when you want information. The units are versatile and can even be used for recreation. For example, you can obtain programs for space games or games of chance that the whole family can enjoy.

Another approach in computer analysis is to have a terminal located on your farm that communicates with a remote computer. You and other users share the cost of having the computer professionally programmed. You are not responsible for maintenance of the software. This system gives you access to current information—the commodities or stock market prices, for example—at any time of day. Your remote terminal may be a microcomputer such as the ones described above or a simpler machine such as a teletype, which you can rent monthly.

If you have a simple machine such as a teletype, you pay a long-distance telephone bill for all the time during which you have access to the computer when you are entering data. If you have a microcomputer, you can enter the data on the storage unit, and it will be transmitted quickly to the computer for analysis. This procedure cuts down the time during which you are directly connected to the remote computer and reduces your telephone bill.

These applications of computer technology to general farm management are taking place throughout agriculture. The most important development in the dairy industry is that we can now connect specialized equipment controllers and data measurement devices with a microcomputer or a larger management computer. The management computer analyzes the information that is recorded daily for each cow (for example, her milk production and feed consumption). The analysis tells you if a cow is taking in less feed or producing less milk than before. The value of this information will vary from one farm to another. It is very important in large herds where part of the work is performed by hired help and where the manager who must make decisions simply does not have enough time to study information on each cow daily.

WHO SHOULD CONSIDER ON-FARM COMPUTERS?

One agricultural economist was recently quoted as saying that a farmer can afford his own on-farm computer if he has a four-wheel drive vehicle for off-road use or a snowmobile for recreational use. Microcomputers cost about the same as those items and can provide almost as much recreation. In fact, many farmers have purchased microcomputers primarily for entertainment. Others have purchased units primarily for overall farm management. Since those producers have already made much of the investment in hardware and acquired expertise, they can easily expand the system to include the dairy enterprise. A system can be expanded either through preprogrammed software systems, such as the cow calendar (which can be purchased from some of the commercial software vendors) or through custom programs, which the producer can perhaps design as a hobby. Most local community colleges now have microcomputers and can provide assistance in developing specialized software programs. Listed on page 16 are the components of an on-farm computer system and their costs.

A typical on-farm microcomputer for data analysis costs approximately $4,000 to $6,000. The features of a typical system include a central processing unit with 64K memory, a visual display unit, a keyboard, a printer, and a floppy disc system for storage of data and programs. The specialized individual-feeding systems with electronic identification range in cost from about $8,000 to $30,000 dollars, depending upon how many cows are involved and the system purchased. The feeder systems usually come with a specialized microprocessor that is programmed at the factory to handle the information from the feeder stalls about each cow.

The advantage of this system is that because it is preprogrammed you can use it without having any expertise with computers. It will provide you with certain diagnostics about each cow either automatically or upon request. Usually, the type of information you can obtain is limited by the factory programming. The individual-cow identification units are priced between $30 and $70 dollars, depending upon the system. The microprocessor that

The Components of An On-Farm Computer System

Component	*Comments*	*Approximate cost*
Central processing unit (CPU)	32, 48, or 64K.	$1,500 to 3,000
Visual display unit, or cathode ray tube (CRT)	May be combined with a keyboard or sold as a stand-alone unit.	150 to 1,200
Floppy disc drive	One is needed for the program and another for the data disc. Discs may be 5 1/4 or 8 inches in diameter and single or double sided.	1,000 to 3,500
Modem	Necessary if you communicate with a remote computer by telephone.	
	300 baud	200 to 300
	1,200 baud	800 to 1,000
Printer	Vary widely in speed, quality of printing, and size of print.	300 to 2,000
Electronic identifiers	Neck units (1 per cow).	30 to 70
Individual feeder stalls	Combined with feed delivery system (one for each 25 to 30 cows).	1,200 to 1,600
Microprocessor for control of feed dispensing	Can handle several feeder stalls.	5,000 to 7,000

Note: Components can be purchased separately or in a complete, integrated system.

decodes information may either be designed to serve as a stand-alone unit or to communicate with another computer. The advantage of the latter design is that you can summarize the data however you wish and are not limited to the microprocessor's factory programming. Automatic milk flow meters have been in operation for about three years in the U.S. However, these meters were not designed to be used in conjunction with automatic identification. Instead, each cow must be identified manually and her number punched in by the parlor operator. Most milking machine companies are developing milk flow systems or automatic meters and several have submitted them to the Dairy Herd Improvement Association for testing. Most of the new meters are designed to be linked to electronic identification. They are intended to be part of a totally automated system for recording milk production. Some of these systems are expected to be on the market in 1982. The new meters, like the new feeder systems, will generally require a separate microprocessor to decode the electronic impulses and put them in a form that will be meaningful to the dairy manager. It will probably be possible to buy the automatic milk recording or feeding system and the electronic identification system either separate or together. Some of the systems are designed to be interfaced with on-farm microcomputers or general purpose computers so that dairy producers can use programs they have designed. Some companies may design programs that will be simple to operate at the farm level. The obvious disadvantage of these programs is that the manager can get out of the computer only what the manufacturer has programmed into it. If the unit is capable of two-way communication with another unit, the farmer can use a program that will get whatever information he wishes from the unit. Listed on page 17 are the components of a herd management data base for individual cows (left) and examples of information commonly obtained from computer-based records systems (right).

WHO SHOULD DEVELOP ELECTRONICS AND AUTOMATION FOR DAIRY MANAGEMENT?

In a free enterprise system such as that found in the U.S., there will be many opportunities for application of computer technology to the dairy industry. Many of the programs will be written by commercial computer vendors and commercial programmers. The programs

Inventory of Data on File	Common Management Lists
Identification Name or number and birthdate Sire and dam	Cow inventory Breeding status, classification, CI, and value
Reproduction Date fresh and calf identification Breeding dates, pregnancy check, and due date	Cows to check for pregnancy Breeding problems No estrus 45 days postpartum Not bred 80 days postpartum
Performance Total lactation to date	Cows due to freshen
Current status Daily milk production Grain allotment and consumption String and value	Cows due to dry off Cows due back in estrus
Health Vaccinations Illnesses and treatments	

should be written so that the information most needed by dairy producers can be obtained from them. Many of us worry that some producers will buy systems that do not have the capabilities they need.

Data analysis systems especially suited to the dairy industry could be developed in many ways. The most logical approaches are to integrate these systems into the Dairy Herd Improvement Association's testing program and to develop them through the service arm of the milk marketing co-ops. Farm service co-ops also have terrific opportunities for developing data analysis systems as part of their overall farm management programs. The dairy industry should demand that programs to meet their needs be developed along with the general farm management programs. It will probably be possible to obtain information by computer from dairy breed associations and the artificial insemination organizations if they decide to distribute information in that way. For example, pedigrees could be obtained directly from breed associations by a computer line upon request. Many other applications of computer technology are possible. The possibilities are limited only by our imagination and, of course, by our willingness to invest in this technology.

University of Illinois Research Reports

Milk Protein: A Review of Its Synthesis and Regulation

JAMES L. ROBINSON AND JIMMY H. CLARK

The protein content of milk is very important in determining its nutritional value. Component pricing of milk is currently being used in some parts of the U.S. If component pricing becomes a major pricing system for milk, increasing the protein content of milk might raise milk prices. As part of the Dairy Herd Improvement program, the protein content of milk from 1,400 cows in Illinois is being tested monthly. Milk protein synthesis and its regulation is an exceedingly complex process. As research improves our knowledge of protein synthesis, strategies for increasing milk protein production can be developed that will benefit both the dairy producer and the consumer of dairy products.

A high-producing dairy cow that yields 100 pounds of milk daily secretes over 3 pounds of protein, which constitutes from 3 to 3.5 percent of the milk. As indicated in Table 1, milk from Guernsey and Jersey cows has more protein than that from the other breeds, on the average, but there is considerable variation among animals within each breed. Milk proteins can be separated into two fractions, casein and whey. Table 1 summarizes the distribution of proteins in milk from various breeds of dairy cattle. The caseins constitute over 80 percent of the proteins in milk. Lactalbumin and lactoglobulin are the predominate whey proteins.

Table 1. Proteins in Skim Milk From Various Breeds

	Ayrshire	Brown Swiss	Guernsey	Holstein	Jersey
			percent		
CASEINS					
Alpha-casein	1.71	1.83	1.92	1.58	1.83
Beta-casein	0.85	0.84	0.82	0.60	0.76
Gamma-casein	0.08	0.11	0.14	0.20	0.13
Total casein	2.64	2.78	2.88	2.38	2.72
WHEY PROTEINS					
Alpha-lactalbumin	0.11	0.11	0.11	0.13	0.15
Beta-lactoglobulin	0.31	0.31	0.35	0.30	0.39
Immunoglobulins	0.06	0.07	0.08	0.09	0.08
Serum albumin	0.03	0.04	0.04	0.04	0.04
Total whey protein	0.51	0.53	0.58	0.56	0.66
TOTAL PROTEIN	3.15	3.31	3.46	2.94	3.38

Serum albumin and immunoglobulins, which represent about 5 percent of the milk proteins, are synthesized in the liver and transported unchanged from blood to milk. The major milk proteins—including the caseins, alpha-lactalbumin, and beta-lactoglobulin—are synthesized in the secretory cells of the mammary gland. The structure of a secretory mammary cell is illustrated in Figure 1.

Just as a dairy producer must have lumber and concrete blocks to build a barn, the mammary cell must have certain materials to synthesize milk protein. The building materials for synthesizing milk protein are amino acids. There are 20 different amino acids, and each is needed to synthesize milk protein. Amino acids are of two types—essential and nonessential. Essential amino acids cannot be made by animal tissues in quantities large enough to maximize milk protein synthesis. Therefore, they must be supplied by feed protein that escapes degradation in the rumen and bacterial protein synthesized in the rumen. All essential amino acids that are used for milk protein synthesis are absorbed from the blood across

the basal membrane of the mammary cell. Nonessential amino acids are obtained by absorption from the blood and by synthesis in the mammary cell from other nitrogenous compounds, including essential amino acids.

From 100 to 200 of these amino acids are hooked together to form milk proteins. Chemical bonds bind the amino acids together in the form of protein in much the same way that nails, bolts, and mortar hold the lumber and concrete blocks together to form a barn. The synthesis of milk protein occurs on the endoplasmic reticulum of the mammary cell (Figure 1), which in my analogy corresponds to the location on the farm where the barn is constructed.

The order in which the amino acids are hooked together to form milk protein is very specific and is determined by genetic messages similar to blueprints. These genetic messages are obtained from deoxyribonucleic acid (DNA), which consists of long sequences of nucleotide bases in the nucleus of each mammary cell. In the nucleus, the genetic messages for synthesizing milk proteins are transcribed into ribonucleic acid (RNA), which is made up of copies of the genetic messages that are transported to the endoplasmic reticulum, or building location. At that location, sequences of nucleotide bases in the RNA are translated into sequences of amino acids to synthesize milk proteins. Large structures called ribosomes (corresponding to the carpenters who build a barn), which appear as dots on the endoplasmic reticulum, are primarily responsible for combining the available amino acids in the sequence determined by the DNA. Thus, the genetic messages from the DNA specify the kind of protein to be synthesized, the quantity and order of the amino acids used for milk protein synthesis, and the efficacy of the various processes involved in RNA synthesis and subsequent protein synthesis.

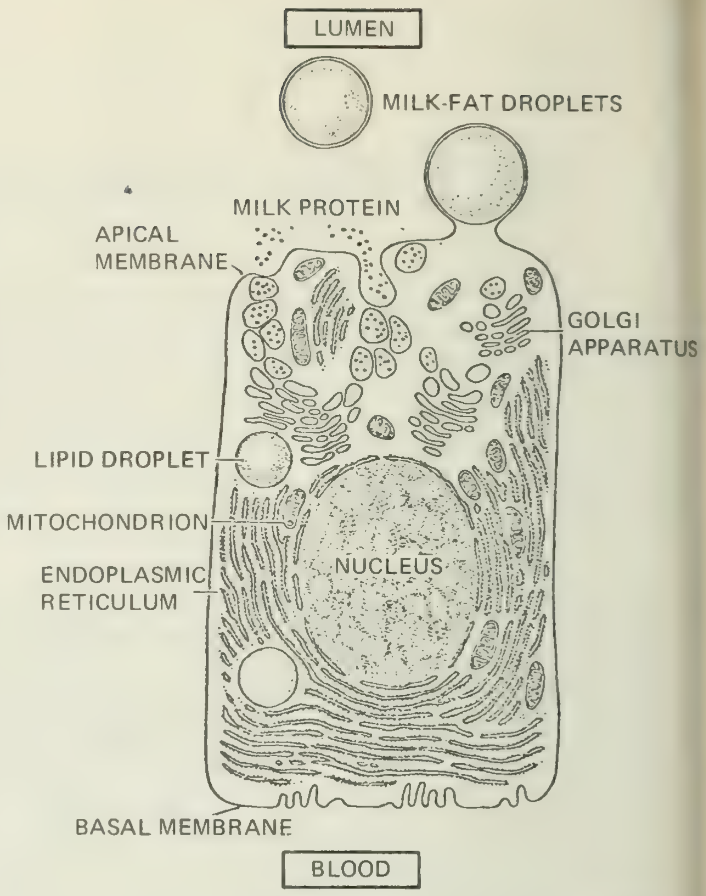


Figure 1. A secretory cell from the mammary gland. Amino acids from the blood cross the basal membrane and are synthesized into protein at the endoplasmic reticulum. The proteins are packaged in the Golgi apparatus, transported to the apical membrane, and secreted into the lumen, along with other milk components.

Upon completion of protein synthesis on the endoplasmic reticulum, the protein is packaged for export from the cell by the Golgi apparatus. The packaged proteins then move to the apical membrane where the protein is discharged into the lumen. The other milk components such as milk fat and milk sugar (lactose) are simultaneously being synthesized and secreted from the cell. All of the milk components then flow through the duct system of the mammary gland to the milk cisterns and are released at milking.

The amount of milk and milk protein that are synthesized is determined by the genetic messages, availability of amino acids and other nutrients, and hormonal regulation. Since the genetic messages control the many processes involved in milk and milk protein synthesis, an effective breeding program can increase milk and milk protein production by altering one or more of the processes described above. Genetic improvement is likely to become much more rapid in the future as the technology for making embryo transfers is improved. Embryo transfer would allow many offspring to be obtained from the same sire and dam mating. In the not-too-distant future, genetic engineering may allow the scientist to alter the genetic messages from the DNA of the mammary cell, resulting in increased milk and milk protein production.

The genetic messages control milk and milk protein synthesis, but the maximum genetic potential of the cow can only be reached if an adequate supply of nutrients such as amino acids, energy, minerals, vitamins, and water are supplied to the mammary cell. Research is constantly seeking to identify nutrients that are in short supply and determine how those nutrients can be supplied economically for milk and milk protein synthesis.

Hormones originating in nonmammary cells play a major role in regulating the quantity of milk and milk protein that is synthesized by the mammary cell, just as resources originating from the local banker regulate the size and speed at which a barn can be constructed. Hormones specifically affect growth and development of the mammary gland, initiation of milk production, maintenance of lactation, partitioning of nutrients to the mammary cell, glucose synthesis, protein synthesis, the milk let-down response, and other metabolic processes that determine productive output of dairy cows.

We will not be able to improve our breeding and feeding strategies for increasing milk and milk production of dairy cows until we fully understand their mechanisms of synthesis and the regulation of those mechanisms. Current research at the University of Illinois is directed toward that objective.

Feeding and Breeding Practices in Illinois DHI Holstein Herds

KATHLEEN A. ROONEY, ROGER D. SHANKS, AND MICHAEL F. HUTJENS

The objectives of this study were to characterize the feeding and breeding practices of various dairy regions in Illinois and to identify trends associated with higher milk production. The Dairy Herd Improvement Association (DHI) records from 1,148 Holstein herds were divided into four regional and milk production groups. Figure 1 shows the four regions into which the state was divided and the concentration of DHI Holstein herds in each county. The northwestern corner has 501 dairy herds, the most in the state. The higher concentration of cheese manufacturing plants in that area suggests that those herds have a higher percentage of fat than the others. The Chicago region (253 herds) and the St. Louis region (202 herds) supply large fluid markets. The rest of the state has 192 herds and supplies milk to a mixture of markets.

The average annual milk production for DHI Holtsein herds in Illinois was 14,348 pounds in April, 1980. To evaluate differences between herds at different levels of production, the herds were divided into four milk-production groups. The lowest group had 286 herds. The milk production of those herds ranged from 7,350 pounds to 13,000 pounds per year. The second group consisted of 269 herds that produced from 13,000 to 14,300 pounds. The third group, consisting of 289 herds, produced from 14,300 to 15,700 pounds. The production of the highest group, which had 304 herds, ranged from 15,700 to 20,970 pounds, the highest average production in the state.

Questionnaires requesting information on feeding and breeding practices were mailed to 1,148 dairy producers in March, 1981. Over 50 percent (591) of the questionnaires were completed and returned. The rest of the

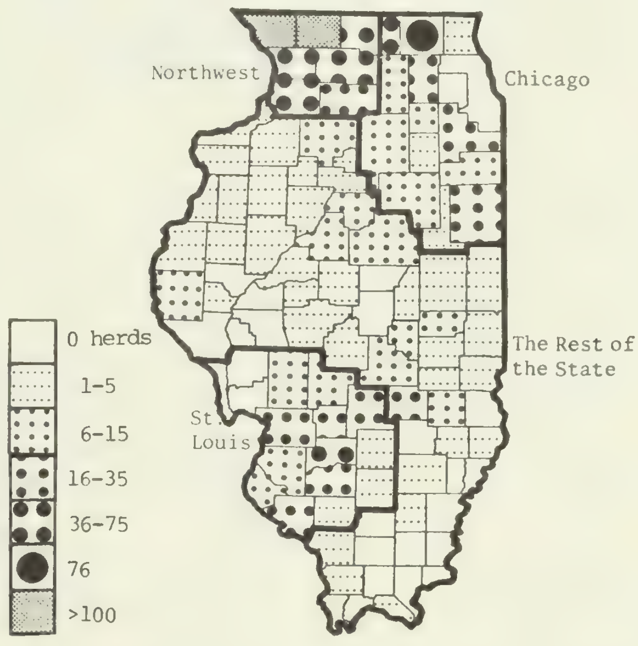


Figure 1. Regional divisions and concentration of DHI Holstein herds by county, 1980.

state region had the highest return rate with 58 percent, followed by the St. Louis region with 53 percent, Chicago with 52 percent, and the northwestern region with 48 percent. Dairy producers that had high herd averages for milk production returned more questionnaires than producers with lower-producing herds. The return rate of the highest milk production group was 64 percent; for the next two groups it was 54 and 53 percent; and the return rate of the lowest group was 34 percent. The feeding practices measured were the use of high-moisture corn, buffers, added fats, electronic grain feeders, and the amounts of forages fed. The breeding practices measured were bulls per 100 cows, number of studs used, use of young sires, consideration for ease of calving, and emphasis placed on different traits in bull and cow selection.

Regional differences in these practices are shown in Tables 1 and 2. The northwestern region reported the highest use of high-moisture corn. Forty-six percent of the responding dairy producers in that region reported that they use high-moisture corn compared with 31 percent in St. Louis, 24 percent in the rest of the state, and 21 percent in Chicago. The addition of fats to the ration increases energy intake when the quantity of feed a cow consumes is limiting. Use of added fats in the diet did not vary significantly among the regions and averaged 10 percent for the entire state. Diets containing buffers were reported to be widely used in Illinois. Forty-nine percent of the responding dairy producers reported that they use them. The St. Louis region reported the highest use of electronic grain feeders. They were used by 30 percent of the producers, compared with 18 percent in the rest of the state, 11 percent in the northwestern region, and 10 percent in Chicago. Producers in the northwestern region fed more haylage and less corn silage than those in any of the other regions. Chicago producers fed the most hay and corn silage and the least haylage.

The number of studs used per herd was highest in the St. Louis region and lowest in the northwestern region (Table 2). The number of bulls used per 100 cows did not vary among the regions and averaged 23 for the entire state. The northwestern region and the rest of the state put the most emphasis on ease of calving. Producers in the St. Louis region reported the highest use of young sires (39 percent) and those in Chicago the lowest (16 percent).

To determine the goals of bull and cow selection, we asked dairy producers to rate 11 bull traits and 9 cow traits. High-producing herds rated all traits more highly than low-producing herds. To determine the relative importance of each trait, its score was deviated from the average of all the traits.

Table 1. Regional Differences in Feeding Practices

Region	Number of herds	High-moisture corn	Added fats	Buffers	Electronic grain feeders
		Percentage of herds			
Northwest	241	46	11	56	11
Chicago	131	21	6	42	10
St. Louis	108	31	7	48	30
The rest of the state	111	24	13	48	18
The entire state	591	34	10	49	16

Table 2. Regional Differences in Breeding Practices

Region	Number of herds	Number of studs used	Bulls per 100 cows	Ease of calving for heifers	Ease of calving for cows	Use of young sires
			Percentage of herds			
Northwest	241	1.8	21.5	92	20	31
Chicago	131	2.3	24.1	82	15	16
St. Louis	108	2.6	23.3	81	12	39
The rest of the state	111	2.2	23.9	86	21	28
The entire state	591	2.1	22.9	87	17	29

The regions varied only slightly in the relative emphasis placed on traits in bull selection. The northwestern region placed more emphasis on predicted difference (PD) fat test and PD fat than the other regions, and St. Louis producers placed the least emphasis on those traits. In the entire state, PD milk and udder traits were considered the most important criteria. Feet and legs were considered the next most important, followed by PD type, PD fat test, and stature. PD fat, PD dollars, and total performance index (TPI) were considered least important. The criteria reported to be least important in choosing bulls were semen price and bull popularity.

In cow selection, the northwestern and Chicago regions placed more emphasis on fat test than the St. Louis region and the rest of the state. Overall, milk production was considered the most important trait in cow selection. Udder traits, feet and legs, and fat test were the next most important criteria followed by longevity and reproductive and mastitis histories. Stature and final score were considered least important.

An important question to ask in discussing feeding and breeding practices is, Which of these aspects are associated with high milk production? In analyzing the milk production groups, the regional effect was first removed. The amounts of forage fed did not vary with the level of milk production. Variations in other practices are shown in Tables 3 and 4. Higher milk production was associated with the increased use of high-moisture corn, buffers, bulls per 100 cows, studs, and young sires. Producers with higher-producing herds tended to consider ease of calving less important for both heifers and cows than did producers with low-producing herds. In all production groups major emphasis was placed on PD milk in bull selection. Producers with lower-producing herds placed more emphasis on that trait than on all the others. Emphasis on udder traits was equally high in all production groups. TPI, PD type, and popularity received less emphasis in the lower-producing herds than in the high-producing herds. In cow selection milk production received the most emphasis in all production groups. Producers with higher-producing herds placed less emphasis on fat test and reproductive history and more emphasis on final score than did producers with lower-producing herds.

The authors are grateful to the dairy producers of Illinois for their contribution to this study and to the DHI Records Processing Center at Ames, Iowa, for providing records.

Table 3. Differences in Feeding Practices Among Production Groups

Milk production groups, pounds	Number of herds	High-moisture corn	Added fats	Buffers	Electronic grain feeders
		Percentage of herds			
7,350 to 13,000	98	20	9	42	17
13,000 to 14,300	143	28	12	45	18
14,300 to 15,700	156	34	5	44	14
15,700 to 20,970	194	34	11	56	19

Table 4. Differences in Breeding Practices Among Production Groups

Milk production groups, pounds	Number of herds	Number of studs used	Bulls per 100 cows	Ease of calving for heifers	Ease of calving for cows	Use of young sires
			Percentage of herds			
7,350 to 13,000	98	1.8	22.8	89	24	20
13,000 to 14,300	143	1.8	19.9	83	23	22
14,300 to 15,700	156	2.1	21.6	89	18	27
15,700 to 20,970	194	2.7	26.8	82	9	38

Selection for Average Daily Gain in Dairy Cattle

SUWAT RATTANARONCHART, MICHAEL GROSSMAN, AND ROGER D. SHANKS

Dairy cattle are becoming a more important source of market beef in the U.S. because of demand from fast-food restaurants. Most of these restaurants serve hamburger, which does not have to be high-quality meat. In breeding dairy cattle, we need to select females for high milk production and males for high meat production.

Growth rate, which is measured as average daily gain (ADG), has an important effect on the efficiency of meat production. Faster growth reduces the cost of both feed and nonfeed items. ADG is computed from records of body weight. A simple method of computing ADG is to divide the difference between the final and initial body weights by the number of days it took to reach the final weight. This method ignores information provided by intermediate body weights. The weakness of this method has been demonstrated by analysis of feeding trials. The analysis shows that the pattern of animal growth is a curve, not a straight line. Later body weights depend partly upon previous body weights. This dependency is taken into account by a method that uses all records on body weights. That method of analysis is called "weighted least-squares regression of body weight on day." The question to ask is whether ADG can be calculated more accurately by the all-records method or by the simple method.

To determine the difference between the two methods of estimating ADG, we generated body weights by computer for each cow and bull from its known ADG. The method of estimation that gave estimates of ADG that were closer to the true values was considered better. The data obtained show that using all records on body weights gave slightly better estimates of ADG.

Heritability is fundamental in animal breeding because it indicates the relationship between inherited and observed measurements. Traits with higher heritability can be more easily improved by selection than those with lower heritability. The results of several studies indicate that ADG, whether it is calculated by the simple method or the all-records method, is heritable enough to be selected (10 to 40 percent of the observed variation is due to genetic differences). The expected response to selection for ADG would be an increase in body weight per day of 0.11 to 0.44 pounds (0.05 to 0.2 kilograms). The results of our research indicate that the components of heritability of ADG can be calculated three times more accurately by the all-records method than by the simple method.

There has been concern that selecting for ADG may decrease milk production. If that is so, progress in selection for both traits will be slow. Other research reports show no genetic correlation between those two traits. More research is needed to clarify the correlation between milk production and ADG, particularly as calculated by the all-records method.

If we select dairy bulls for ADG, we should estimate ADG by the all-records method. The body weights of steers and heifers should be calculated periodically from heart girth, body height, and length. This calculation can be made by the dairy producer.

Recycling of Dairy Cattle Manure Waste

EDWARD H. JASTER

Two types of wastes result from a dairy farm, the solid manure waste from dairy cattle and the liquid wastes from cleaning the milking parlor. Some dairy producers treat liquid and solid wastes separately. Others mix wastes together and transport and dispose of them as a liquid. Disposal of manure by either method is a major problem. Some producers must haul manure daily, and in some areas environmental pollution is a problem.

Manure production from dairy cattle averages 86 pounds per animal per day and represents to 8 percent of the body weight of the animal per day. The alternative to disposal of arge quantities of manure may involve storage and possibly recycling. Earthen lagoon basins nd aboveground storage are two types of manure storage systems. Aboveground storage allows cheduling of manure hauling to reduce runoff. It reduces loss of nutrients and makes it ossible to recycle the fiber portion of manure.

An integral part of the University of Illinois dairy farm manure recycling system is a olid-liquid separation unit. The unit processes dairy waste from our free-stall barns and pen lots with a perforated, pressure, roller-type separator. Two products come from the aste during solid-liquid separation—effluent liquid slurry and dairy waste fiber (DWF). he dairy waste fiber is high in fiber components, notably in cellulose and lignin (Table 1). fter the dairy waste fiber is removed, the liquid slurry, which retains most of the major lant nutrients, can be incorporated into the land and assimilated by field crops. The pproximate nitrogen composition of the liquid slurry is 0.5 percent. The fiber product obained from separation can be used as a livestock bedding, feed source, or soil mulch. After urther processing, it can also serve as an energy source.

AIRY RATIONS INCORPORATING DAIRY WASTE FIBER

Refeeding the solid portion of dairy aste fiber as an ensiled product with hayage or corn silage has had positive results. n deciding whether to include recycled dairy anure in rations for dairy cattle producion, we must consider ration palatability, nimal performance, ease of handling, quality f the product, economic return, and consumer cceptance. We do not yet have sufficient ata on milk or meat quality and consumer aceptance to draw any conclusions. But so far o serious problems have been encountered n these matters. The economic feasibility f manure refeeding will depend largely on the dairy farmer's capacity for storage and sepaation and on the prevailing prices of comparable nutrient ration components.

Table 1. Nutrient Composition of Dairy Waste Fiber

Nutrient	Percent
Moisture	72.0
Ash	12.9
Nitrogen	1.4
Neutral detergent fiber	77.2
Acid detergent fiber	54.2
Acid detergent lignin	17.1
Cellulose	37.1
Hemicellulose	23.0

Ease of handling, mixing, and storage of waste fiber can be accomplished on most dairy arms that are equipped to feed complete rations. Dairy waste fiber is normally fed as a lended ration with haylage or corn silage either fresh or ensiled. Be careful when switchng ration components to dairy waste fiber because palatability may be a problem if levels re not carefully controlled and mixing and storage are poorly managed.

ESEARCH ON THE FEEDING OF DAIRY WASTE FIBER TO DAIRY CATTLE

During feeding experiments at the University of Illinois, separated dairy waste fiber as been successfully incorporated with corn silage at the time of ensiling up to a level of 0 percent of the total dry matter (Table 2). Dairy heifers were fed increasing levels of ietary dairy waste fiber (from 15 to 30 percent), resulting in increased intake of dry atter and decreased digestibility of dry matter. Feeding corn silage ensiled with dairy aste fiber at 0 to 15 percent dry matter resulted in no significant difference in dry matter ntake or digestibility of crude protein, hemicellulose, or cellulose. However, increasing he dairy waste fiber from 15 to 30 percent dry matter significantly reduced digestibility f dry matter, crude protein, and cellulose (Table 2). Feeding dairy heifers rations conaining 15 percent DWF has no detrimental effect on dry matter intake or fiber digestibility.

EPARATED SOLIDS FOR FREE-STALL BEDDING

Recent reports on increased incidence of mastitis in dairy cows has raised some concern bout the use of dairy-waste fiber as a bedding material. Researchers at Brigham Young Uniersity substituted manure solids for sawdust in their free-stall unit to reduce the high ost of bedding. After they had begun using manure solids, the incidence of clinical mastitis ncreased. Culture results showed a rise from 7 percent to 46 percent coliform mastitis, rimarily *Eschlerichia coli* (E. coli), after the switch from sawdust to separated manure olids. Use of manure solids as bedding was discontinued, and sawdust was used again. The

Table 2. Intake and Digestibility of Dry Matter and Fiber Components in Diets Fed to Heifer

Dry matter and fiber components	Intake (ad libitum) at various corn silage-to-DWF ratios			Digestibility at various corn silage-to-DWF ratios		
	100:0	85:15	70:30	100:0	85:15	70:30
		Pounds per day			*Percent*	
Dry matter	20.9	20.9	22.4	55.9	53.6	45.8
Neutral detergent fiber . .	10.3	11.2	13.2	43.7	42.6	39.5
Acid detergent fiber	6.2	6.6	7.5	49.4	48.8	38.7
Acid detergent lignin . . .	0.9	1.1	1.3	18.0	15.3	8.4
Crude protein	2.9	2.9	3.1	51.7	52.1	48.7
Cellulose	5.3	5.7	5.9	55.0	53.7	45.4
Hemicellulose	4.2	4.6	5.7	35.0	35.6	40.4

mastitis situation improved, but because the cost of sawdust was prohibitive, research with separated solids continued. Recently, workers at Brigham Young found that composting the separated solids in stacks increases the temperature inside the stack to about 130°F after three weeks. This high temperature reduces the number of coliform bacteria. The coliform count in freshly separated manure solids (60 percent dry matter) was 1 million per gram; few coliforms were found after three weeks of composting. Composted separated solids were place in the free stalls as bedding, and no adverse effects were reported. Listed below are some management tips to follow when separated manure solids are used for bedding.

1. This practice creates some risk of coliform mastitis. Use a dry cow treatment containin drugs with both gram negative and gram positive spectra.
2. Manure solids should not be used until the coliform count is below 1 million per gram.
3. Manure solids should be at least 60 percent dry matter or higher before they are used. In Utah this level is reached by composting solids for five weeks and storing it in covered sheds during wet weather.
4. Solids may become recontaminated with coliform organisms in the free stalls, and the cows' udders and sides may become highly contaminated. Make every effort in the parlor to see that the udder is washed carefully and that prep water does not run off the animals' flanks onto the udder and the top of the inflation during milking.
5. Always dip teats after every milking.
6. Keep animals on their feet for at least an hour after milking to allow closure of the teat sphincter.
7. The manure solids used as bedding should be built up slowly to avoid high moisture and heating in the deep portions.
8. Be on the lookout for coliform mastitis.

Electronic Identification of Cattle: Subdermal or External?

SIDNEY L. SPAHR, HOYLE B. PUCKETT, RARJIT S. FERNANDO, AND GENE C. McCOY

Electronic identification of cattle is now a reality. Several companies are now marketing electronic feeder systems. These systems have a microprocessor that enables them to dispense predetermined amounts of feed to each cow. As the cow enters the feed stall, it is identified automatically by means of an electronic identifier fastened around its neck.

Another approach in electronic identification is to implant the identifier permanently beneath the cow's skin. A particularly attractive feature of this approach is that we can then monitor subdermal temperature as well as identify the animal. The purpose of this report is to present our findings on a subdermal-identification and temperature-monitoring system.

The system we used was patterned after technology developed at Los Alamos Scientific Laboratory, Los Alamos, New Mexico, and was manufactured by Identronics, Inc., Santa Cruz, California. The system utilizes electronic identifier units that are surgically implanted just beneath the skin on the left side of the animal behind the shoulders in the crops region. The identifiers do not have batteries. They receive their power from an external source as the animal passes through a field of microwaves. Each identifier has a capacity of approximately 65,000 digital numbers.

When the system is in operation, an interrogator, which is a microcomputer-based unit, sends a radio frequency signal toward an identifier through an antenna. The identifier returns a coded message that is received by the same antenna and transmitted to the interrogator for decoding and storage. One interrogator in a central location can handle several antennas.

In our experiment subdermal identification units were implanted in 20 heifers, 13 to 16 months of age, in October, 1979. The heifers were identified and their temperatures monitored each time they drank water during a 61-day period beginning in March, 1980. Our objective was to determine why temperature varies among animals, according to the time of day, and from one day to another. Each entry by an animal was recorded and averages were calculated for each 15-minute period.

We found wide variation in temperature from one animal to another, from one day to another, and from one hour of the day to another. The large variation among animals is apparently caused by differences in the animals' metabolism and in the amount of insulation around the identifier. Each animal has its own characteristic subdermal temperature. This fact must be considered any time temperature is monitored for physiological purposes.

Table 1. Variation in Subdermal Temperature

Variable	Number	Range
Animals	20	29.3° to 35.2°C
Days	61	28.1° to 33.4°C
Hour of day	24	30.1° to 33.1°C

Note: Overall mean—32.5°C

Variation according to the time of day followed a pattern similar to expected changes in ambient (outside) temperature. During the daylight hours, increased animal activity and metabolism added to the effect of higher ambient temperature upon subdermal temperature. Our method of obtaining readings (when an animal voluntarily came to drink water) did not allow us to monitor temperature on all animals at the same time of day. The results demonstrate clearly that time of day would have to be taken into account in any system of physiological monitoring designed to locate animals that are ill.

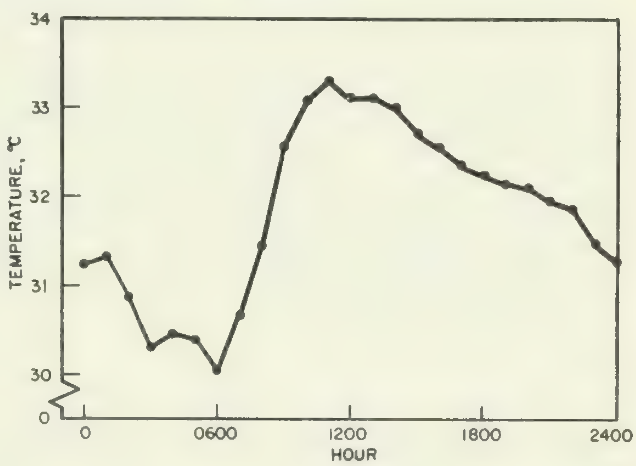


Figure 1. Hourly variation in subdermal temperature.

Average ambient temperature had little relation to subdermal temperature from one day to another. However, rainfall did have a significant effect on day-to-day variation. Apparently, the cooling effect of rain on the animal's skin reduces its subdermal temperature.

Several conclusions were reached about the reliability of the system. All animals could be identified electronically during the trial. The trial started approximately 5 months after implantation in October. Surgical implantation substantially reduced the range with which the units could be interrogated. Large variations in the interrogation range from one identifier to another were observed. With some identifiers it was necessary to get as close as 10 inches to obtain a satisfactory reading. In contrast, the identifiers could be read at a range of 5 yards or more before implantation. One identifier was expelled after the trial ended (about 7 months after implantation), and another was recently rejected.

In summary, subdermal temperature varied according to the time of day, the individual animal, and rainfall. It appears that if subdermal temperature is to be useful for routine

herd management, animals will need to be monitored at about the same time of day, and the individual animal profiles will need to take into account each animal's normal variation from the herd mean.

Changes in Carbohydrate-Fermenting Bacterial Groups in the Rumen

JANE A.Z. LEEDLE, MARVIN P. BRYANT, AND ROBERT B. HESPELL

Ruminant animals depend upon vigorous fermentation by microorganisms in the rumen. These microorganisms degrade cellulosic carbohydrate feed into microbial products that are absorbed and used by the ruminant animal. The microorganisms also use the feed to support their own growth and multiplication. The microbial cells that are produced eventually pass from the rumen to the lower tract where they are degraded by host animal enzymes. Thus, microorganisms yield a substantial portion of the ruminant animal's nutritional substrates.

The ruminant animal and microbes have a mutually beneficial relationship. The animal provides an environment in which the microbes can grow and reproduce. The microbe produces food from carbohydrate sources that otherwise would not benefit the host animal. This complex relationship has been studied extensively because of its relation to the production of meat and milk. Through these investigations, we have learned that to improve meat or milk production we must first thoroughly understand the microbial community that is responsible for providing substrates for the ruminant animal's nutrition.

The microbial community in the rumen is a diverse collection of non-spore-forming anaerobic bacteria, protozoa, and fungi. Although the latter two groups play a role in the overall ecology of the rumen, their contribution is not discussed here. The bacteria population is by far the largest and most thoroughly studied of all the groups. Over the years, dozens of species have been isolated and identified. Each has been tested for the types of carbohydrate substrates it can degrade, utilize, or both. Based upon the findings of those tests, it has been possible to assign each species to a functional group or groups that are responsible for degrading major carbohydrate components in the ingested feed. These groups include species that are capable of degrading soluble sugars, starches, pectins, hemicelluloses, celluloses, or some combination.

Recently, in our laboratory anaerobic plating methods were developed by which we can rapidly determine the size and distribution of the carbohydrate-degrading groups of bacteria within the mixed bacteria population of the rumen. This method makes it unnecessary to first isolate and identify individual species. Differentiation of the functional groups is based upon carbohydrate utilization. A number of recovery media were prepared, each of which contained a single carbohydrate substrate. After inoculation and incubation, the ruminal bacteria growing on each recovery medium indicated the carbohydrates the bacteria were fermenting at the time of sampling. As a result, we can monitor the total rumen bacteria population *in vitro* (outside the animal) quickly, easily, and under conditions similar to those in the rumen.

In a series of investigations, we used this method to examine the diurnal (daily) variation in groups of carbohydrate-fermenting bacteria after a single feeding at 7 am. We fed rumen-fistulated Holstein steers (1,100 pounds) maintenance-level diets formulated on a metabolizable-energy basis. To bring out the differences among bacteria groups, a high-concentrate diet supplying 75 percent of the calories in the form of concentrate (remainder as hay) was fed for half of the experiments. In the other experiments, the steers were fed a high-forage diet in which 75 percent of the calories were derived from alfalfa hay (remainder as concentrate). To determine the patterns of diurnal variation, the rumen was sampled manually at 0600, 0900, 1100, 1500, 1900 and 2300 hours. These times corresponded to -1, 2, 4, 8, 12, and 16 hours after feeding. At the same time, the bacteria in the rumen were collected, and several rumen parameters were measured, including pH, ammonia, carbohydrate, and fermentation acid concentrations.

The results showed that the total number of bacteria remained fairly constant throughout the period regardless of the type of diet fed. The number of culturable bacteria sharply decreased after feeding, reaching its lowest level 2 hours after feeding. The number then gradually increased, reaching its highest level 16 hours after feeding. There were small changes in the major carbohydrate-fermenting groups within the bacteria population of the steers on either diet. In general, those changes were not related to the normal pattern for fermentation of the major dietary carbohydrate components in the rumen.

The most striking observation was that soluble-carbohydrate-fermenting bacteria predominated at all times after feeding. This was unexpected because the levels of soluble sugars are usually extremely low in the rumen except immediately after feeding. One explanation for this observation is that the majority of bacteria in the rumen can use soluble sugars for growth. Bacteria that ferment hemicellulose (xylan) comprised about one half and those that ferment pectin about one third of the population in the rumen samples collected from the animals fed a high-forage diet. Those groups comprised a smaller percentage of the population when the animals were fed the high-concentrate diet. The differences were thought to reflect the nature of the major carbohydrates in the diets. Although the cellulolytic bacteria were the smallest group of those tested, they showed the most distinct pattern of diurnal variation. The number of culturable cellulose-degrading bacteria dropped substantially after feeding, possibly because the bacteria are oxygen sensitive or were able to attach to incoming feed particles. The number increased after 8 hours, reaching its highest level 16 hours after feeding. This increase might be due to multiplication within the cellulolytic group, dislodgement (and hence detection) from fragile, disintegrating feed particles, or both.

Other measurements confirm that the population of bacteria was relatively constant over the diurnal period studied. Fermentation acids remained near 100 millimolar, ammonia levels around 14 millimolar, and carbohydrate concentration near 120 micrograms per milliliter. Of particular interest, however, was the finding that the diurnal pH profiles did not change much between diets. Generally, diets that are high in concentrate materials are associated with lower pH (often below 6.0) in the rumen soon after feeding. Although the pH did decline slightly after feeding, no sharp decrease was detected.

The apparent lack of difference between the carbohydrate-fermenting bacteria of animals that were fed high concentrate and those that were fed high-forage diets was unexpected. Previous work indicated that large differences would be detected between the two diets. Close inspection of the previous data revealed that the diets compared had been formulated on a dry-matter basis. Thus, the high-concentrate diet, by the nature of its components, contained more energy per unit of dry matter than did the high-forage diet. In our studies, both diets provided the microorganisms in the rumen with equivalent amounts of calories. The amount varied only with the form of the predominant caloric materials. Consequently, neither diet caused production of fermentation acids in the rumen that surpassed the normal buffering capacity of the saliva and blood. These data suggest that normal rumen function is not disturbed simply by the type of diet fed. The important factor is the overall level of feeding, especially of concentrate diets. Too high a level will provide more calories than can normally be fermented and assimilated. Our data show that the pH of the rumen is a primary factor governing the size and composition of the rumen's bacteria population.

These preliminary studies are the first to relate numbers and types of bacteria to many important parameters of the rumen. They are a first step in relating ingested feed carbohydrate and carbohydrate fermented with the major groups of bacteria that are responsible for that fermentation. The ability to determine the size and distribution of the carbohydrate-fermenting bacteria brings us closer to estimating accurately the extent of substrate fermentation taking place in the rumen at a given time. We may eventually discover ways of increasing the fermentation rate of ingested feed by manipulating bacteria groups.

Methanol Fermentation in the Rumen of Molasses-Fed Animals

BARBARA SHARAK-GENTHNER, MARVIN P. BRYANT, AND CARL L. DAVIS

In tropical countries molasses is sometimes a major ingredient in the rations of cattle and sheep because it is readily available and relatively inexpensive. It is also an ingredient of feed for the ruminant animal industry in the U.S. where it is either mixed with othe feedstuffs or provided as a liquid supplement in lick tanks. Although heavy use of molasses has certain advantages, complications can arise. Because the feed efficiency of the animal is often low, the syndrome called "molasses toxicity" may result. Animals may go off feed, become disoriented, have spastic attacks, and show visual impairment. Untreated animals may die. Recent work in Central America and Australia has indicated that with molasses-fed animals the retention time for materials in the rumen may be prolonged. This leads to a breakdown of fatty acids, such as acetate, to carbon dioxide and methane by methanogenic bacteria. As a result, less energy is available to the animal. The prolonged retention of materials in the rumen may also reduce drastically the amount of microbial protein available to the animal.

In a recent study at the University of Illinois, sheep were fed once each day a ration of 2.2 pounds of a liquid molasses mixture and a dry feed consisting of 0.18 pounds of soybea meal and 0.22 pounds of chopped wheat straw. The molasses mixture contained 93 percent blackstrap molasses, 3 percent urea, 2 percent minerals (salt, trace minerals, and dicalcium phosphate), and 2 percent added water. Sheep that were fed this high-molasses diet did not develop any adverse symptoms, and the major bacteria in the rumen were very different from those expected.

The rumen fermentation in these sheep was very unusual. The animals ate the dry portion of the diet (straw and soybean meal) soon after feeding and continued consuming the liquid portion of the diet over a period of 6 to 8 hours. The rumen contained high levels of the volatile fatty acids (VFA) acetate and butyrate and a surprisingly large amount of caproic acid, but the level of propionic acid was extremely low. Methanol (wood alcohol) was present in the rumen while molasses was being eaten, and branch-chained volatile acids (isovalerate and isobutyrate) reached a high proportion of the total VFAs after the animals had consumed the molasses. The major bacterium that we expected to find, *Methanosarcina*, was not found. It grows on acetate, methanol, and a mixture of hydrogen and carbon dioxide gas and produces methane. We isolated another predominant bacterium that reflected the major products found in the rumen of the molasses-fed sheep.

The bacterium was identified as *Eubacterium limosum*, a species that we had previously thought only fermented lactic acid and sugar in very young calves. We found it to be the major methanol-fermenting species in the rumen of the sheep. In addition to growing on methanol, it grew on several other energy sources such as a mixture of hydrogen and carbon dioxide gas, lactic acid, and sugars. It produced acetate, butyrate, and caproate. The organism also grew on branch-chained amino acids and made products that included ammonia and branch-chained VFAs such as isobutyrate.

The methanol that is found in the rumen of the sheep and that is effectively used as an energy source by this bacterium is undoubtedly produced during the fermentation of pectin, which is known to be a major constituent of molasses. Many rumen bacteria are known to ferment pectin and produce methanol, various VFAs, and other products such as hydrogen gas. However, only *Methanosarcina*, which produces methane from methanol, was previously known to utilize methanol in the rumen.

This research shows for the first time that under certain conditions the rumen contains bacteria that are capable of producing VFAs, rather than methane, from one-carbon compounds such as methanol and a mixture of hydrogen and carbon dioxide gas. The research also raises a number of important questions: (1) Do animals with this type of rumen fermentation have more efficient feed conversion compared to animals in which one-carbon compounds are converted mainly to methane? (2) In addition to *Eubacterium limosum's* importance in methanol

degradation in the rumen of these sheep, might it also play a major role in the utilization of a mixture of hydrogen and carbon dioxide gas for VFA production? (3) Through basic research on *Eubacterium limosum*, can we determine why it becomes the predominant organism utilizing one-carbon compounds under these special circumstances? (4) Is it possible to increase the numbers of this organism so that it can be an important contributor to rumen fermentation under other dietary regimes? (5) Might this bacterium become important in industry as a producer of fatty acids, rather than methane, from one-carbon compounds? The finding of methanol in the rumen of these sheep suggests that methanol poisoning might be listed among the causes of molasses toxicity in ruminants. Only further research will give the answers to these questions.

Performance of Lactating Dairy Cows Fed Methionine or Methionine Analog

JIMMY H. CLARK

Methionine is an important amino acid in ruminant nutrition because it is involved in protein and lipid metabolism. It has been suggested that methionine is the most limiting amino acid for the lactating dairy cow. Methionine is an essential amino acid for milk protein synthesis and a major precursor in the synthesis of serum lipoproteins. It is involved in deposition and mobilization of adipose tissue and in the transport of lipid in the blood. Any interference in lipoprotein metabolism resulting from methionine deficiency could affect production of milk fat.

Feeding dairy cows nonprotected methionine may stimulate their production of milk, milk protein, and milk fat if dietary methionine is limiting some aspect of microbial metabolism. However, feeding nonprotected methionine will not increase the quantity of methionine absorbed from the small intestine because the rumen microorganisms rapidly degrade methionine in the rumen. Therefore, dairy research on methionine supplementation has centered on protecting methionine from degradation by microorganisms in the rumen and increasing the flow of methionine into and absorption of it from the small intestine. Forming chemical analogs (similar compounds) of methionine is one method that has been proposed for protecting methionine from microbial degradation in the rumen and increasing the quantity absorbed from the small intestine.

A deficiency of methionine may occur when rations containing less than optimal concentrations of crude protein are fed to lactating cows. The objective of the research reported in this paper was to determine the response of lactating cows to supplemental methionine or methionine analog when two concentrations of dietary protein were fed to supply either adequate or marginal crude protein in the diet.

Holstein cows that had completed at least two lactations and were from 17 to 71 days (a mean of 40 days) postpartum at the beginning of the experiment were individually fed to provide either 80 or 100 percent of their crude protein requirements. Within each protein group, treatments consisted of no additive (control), methionine (21 grams per day), or methionine analog (25 grams per day). Each experimental period was 28 days. The first 7 days were for adaptation, and data were collected during the remaining 21 days. The daily ration for each cow consisted of corn silage fed free choice, 5 pounds of alfalfa-grass hay, and a concentrate mixture of ground shelled corn and a protein, mineral, and vitamin supplement. The supplement consisted of 92.375 percent soybean meal, 4.5 percent dicalcium phosphate, 2.5 percent trace mineral salt, 0.225 percent sodium sulfate, and 0.40 percent vitamin A and D premix. The concentrate was fed at a rate of 1 pound for each 2.75 pounds of milk produced. The ratio of corn to supplement was adjusted so that each cow received either 80 or 100 percent of her calculated crude protein requirement.

Cows fed 80 percent of their crude protein requirement produced approximately 6 percent less milk than cows fed 100 percent of the requirement (Table 1). However, this difference was not significant. Milk composition and yields of fat, protein, and solids-not-fat were also unaffected by protein concentration in the ration. Cows fed 100 percent of their crude protein requirements did gain more body weight than cows fed 80 percent of their crude

protein requirements. Compared to the control, neither methionine nor methionine analog had a significant effect on dry matter intake, milk production, or milk composition.

Table 1. Effects of Supplemental Methionine or Methionine Analog on Feed Intake, Milk Production, and Milk Composition When Fed in Rations That Contain Two Concentrations of Crude Protein

	Crude protein concentration					
	80 percent of requirement			100 percent of requirement		
Parameter	Control	Methionine	Methionine analog	Control	Methionine	Methionine analog
Crude protein, percentage of dry matter	11.5	11.4	11.6	14.0	14.1	14.5
Crude protein intake, pounds per day	4.9	5.0	5.0	6.4	6.4	6.5
Dry matter intake, pounds per day						
Hay	4.3	4.2	4.3	4.2	4.2	4.2
Corn	17.2	18.3	17.4	15.5	15.5	14.8
Supplement	2.2	2.3	2.5	5.5	5.6	5.9
Corn silage	18.7	19.4	18.8	20.4	20.2	19.8
Total	42.4	44.2	41.4	45.6	45.5	44.7
Milk, pounds per day	61.8	63.8	62.2	66.4	67.7	65.1
Fat, percent	3.29	3.15	3.42	3.31	3.15	3.27
Crude protein, percent	3.29	3.28	3.25	3.37	3.35	3.35
Solids-not-fat, percent	8.32	8.43	8.36	8.45	8.49	8.43
Body weight gain, pounds per 28 days	20.3	18.3	16.5	24.7	37.4	29.3

Aging Gametes and Fertilization

J. ROBERT LODGE, CHARLES N. GRAVES, ALBERT L. SMITH, AND BRIAN J. MILLER

Dairy science investigators at the University of Illinois have been interested in the influence of the aging of gametes on fertility and embryonic loss for many years. Aging can occur during *in vitro* storage (outside the cow) and in the female reproductive tract as a result of improper timing of insemination. If semen is deposited in the female reproductive tract too soon, the sperm will age before the oocyte (egg) arrives at the site of fertilization. The sperm may already have aged during storage before insemination. If insemination is late, the oocyte will age as it lies in wait for the sperm. Inseminating aged sperm (stored) late thus involves both aged gametes in fertilization. Researchers have previously studied only the influence of aging of one or the other gamete and have not considered the possible consequences of an interaction between aging in both gametes.

An experiment was designed to study the combined effects of aging in both gametes upon fertilization and to investigate the changes in the chromosomes that might be associated with subsequent embryo loss. *In vitro* fertilization, using gametes from the mouse, was chosen as a model. This method enabled us to time precisely the mixing of gametes. An additional advantage was that sufficient numbers of gametes were available at a minimum cost. All combinations of aging sperm and eggs were examined at three-hour intervals over a 24-hour aging period. Sperm were recovered from the tail of the epididymis and vas deferens and aged by *in vitro* storage. The sperm from several males were collected and mixed to prevent influence by any one male. The eggs were aged *in vivo* (in the mouse) by delaying the time of recovery after ovulation. The eggs recovered from several females were mixed to prevent influence by any one female. The egg-sperm mixtures were incubated for 24 hours under controlled conditions for fertilization to be completed.

The fertilization process involves several steps, including the penetration of mem-
ranes surrounding the egg, the development of pronuclei after penetration, and chromosome hanges in preparation for the completion of fertilization. To examine these various steps, ggs were transferred to microscope slides, processed, and stained.

In general, penetration of ova that were ertilized *in vitro* declined as each of the ametes aged (Table 1). Statistical analysis f these data revealed that significant dif- erences in ova fertilization resulted from ging in the egg, aging in the sperm, and rom the interaction of aging in both gametes.

Table 1. The Effect of Aging in Gametes Upon Ova Fertilization

Gametes and age	Percentage of ova fertilized
Fresh sperm and aging eggs	
0 hours	71
12 hours	37
24 hours	4
Fresh eggs and aging sperm	
0 hours	71
12 hours	77
24 hours	33

In examining the various stages of fer- ilization, it was found that aging of sperm, ging of eggs, and their interaction all af- ected the penetration of sperm into the embranes of the egg. These effects were robably due to changes in the membrane and oss of enzyme from the gametes. The effects n the development of pronuclei, which occurs fter sperm penetration, were found to be due primarily to the aging of the egg. Those ffects may also be related to changes in the cytoplasm rather than the nucleus. At the ext step of fertilization, the prometaphase stage, both the aging of sperm and the inter- ction of aging in both gametes had effects. These effects were probably due to the inabil- ty of the aging sperm nucleus to develop at the same rate as the egg nucleus. This imbal- nce upset the timing of events that is necessary for normal fertilization. There were no ignificant effects of aging in gametes on polynuclear (the presence of more than the normal umber of pronuclei is due to polyspermy or failure of expulsion of the second polar body) r other chromosome abnormalities.

The results of this study emphasize the necessity for proper timing of insemination to chieve normal fertilization. With aged (stored) sperm, timing is probably even more im- ortant than with relatively fresh sperm.

The importance of timing is further emphasized by the results of another study now in rogress. Oocytes recovered from cow ovaries are examined to determine the influence of ging of bull sperm on their ability to bind and penetrate the zona pellucida (the outer overing of the egg), which surrounds the oocyte. In the study, bull sperm are stored in olk-citrate at 4°C for 10 days. The sperm's ability to bind to or penetrate the zona ellucida is examined at varying times during the 10-day period. Some results of the study re presented in Table 2.

Table 2. The Influence of Sperm Storage on Their Ability to Bind and Penetrate Oocytes

	Period of sperm storage, days			
	0	4	7	10
Number of eggs	45	30	38	22
Percentage of eggs with bound sperm	93	77	87	68
Average percentage of sperm bound per egg	3.4	3.7	4.1	2.9
Percentage of eggs with sperm penetration	68	50	52	42
Average percentage of sperm penetrating per egg	1.35	1.45	1.45	1.33

The data in Table 2 show that the percentage of eggs on which sperm are bound and are enetrating the zona pellucida decreases as the sperm age in storage. However, with eggs n which sperm are bound or are penetrating, the number of sperm attached to each egg re- ains the same. Additional experiments designed to determine the quantity of acrosomal nzyme in the sperm acrosome suggest that the quantity of enzyme decreases with time. This eduction corresponds to decreases in the percentage of eggs that have bound and penetrating perm. These data will help explain the decrease in fertility with time of sperm storage.

The Effects of Stress on Absorption by the Newborn of Immunoglobulins From Colostrum

CHARLES N. GRAVES AND RAUL MACHADO

Colostrum transmits passive immunity from cows to newborn calves because of its high levels of immunoglobulins. These immunoglobulins, or antibodies, protect the calf from many diseases that cause death or unthriftyness during the early postnatal period. The results of recent studies at the University of Illinois indicate that stress on an animal during the last part of its pregnancy can decrease the amount of immunoglobulins absorbed by the offspring during the critical first days of life.

The studies were conducted on pigs because of the facilities available. Since pigs transfer immunoglobulins to their newborn in exactly the same way that cows do, the results of these studies should be applicable to cows. Stress was applied to the sows by placing them for the last two weeks in gestation in an environmental chamber in which the temperature was increased to 88.9°F. At that temperature it was evident that the animals were under stress. Both their respiration rate and rectal temperature were significantly higher than that of sows maintained either under normal farm conditions or in an environmental chamber where the temperature was not increased. At parturition the temperature of the stress chamber was lowered to that of the chamber containing the control pigs (71.5°F).

The level of cortisol, the hormone secreted by an animal in response to stress, was approximately three times higher in the blood serum of the sows subjected to the higher temperature than it was in the control group. The piglets farrowed by the stressed sows also had higher levels of serum cortisol at farrowing compared to piglets farrowed from the sows in the control group. There was also a higher concentration of cortisol in the colostrum obtained soon after farrowing from the sows that were subjected to higher temperature.

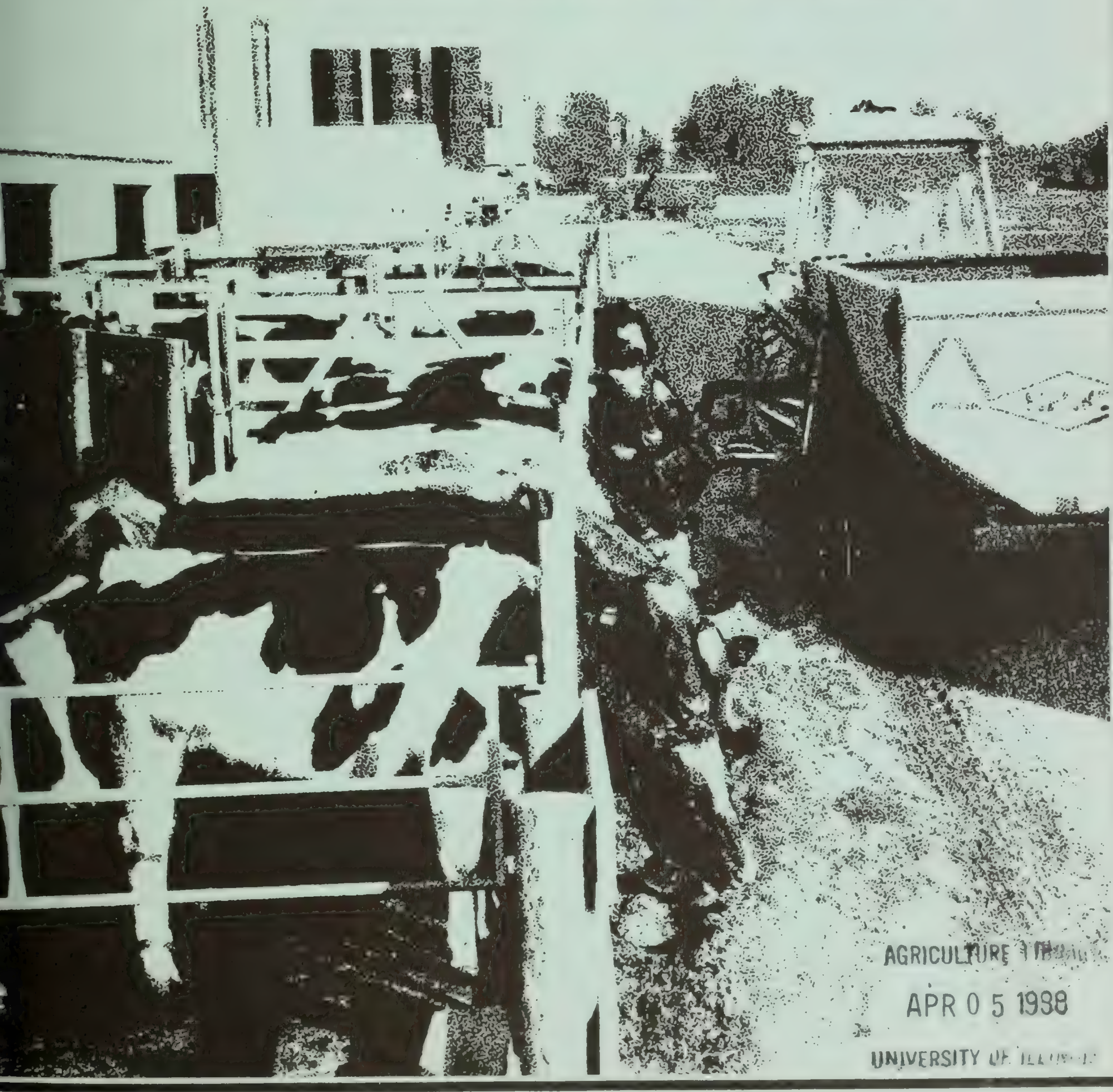
Except for the higher levels of cortisol, no difference was evident between the colostrum of the sows that were subjected to high temperature and that of the control sows. However, the level of immunoglobulins in the serum of the piglets from the stressed sows was significantly lower than that of the piglets from the control sows. In addition, the immunoglobulin level decreased at a faster rate until day 20 postpartum in the piglets of the sows subjected to high temperature. Since none of the piglets were under stress (only the sows were under stress during late pregnancy), no differences were observed in the rate of mortality or gain in weight between farrowing and weaning in the piglets from any of the treatments. However, if stress (in the form of disease or adverse environmental conditions) were applied to the piglets with the lower levels of immunoglobulins in their serum, it is expected that both their mortality levels and growth rate would be affected.

These results suggest that the higher levels of cortisol observed in the serum of the sows under higher temperature might be responsible for the higher levels of cortisol in the piglets at farrowing time. The higher levels of cortisol may in turn be responsible for decreased absorption of the immunoglobulin by the piglets. This decreased immunoglobulin level would make the piglets more susceptible to disease should they come under stress during the critical first few days of life.

1983
Illinois Dairy Report

Department of Dairy Science
Cooperative Extension Service
Agricultural Experiment Station
College of Agriculture
University of Illinois at Urbana-Champaign

Economics and Efficiency



1983 Illinois Dairy Days

January 10 Kankakee, Extension Office
11 Marengo, Shady Lane Restaurant
12 Freeport, Masonic Temple
12 Elizabeth, Community Building
13 Sterling, Emerald Hill Country Club

January 14 Peoria, Extension Office
18 Quincy, Farm Bureau Building
19 Breese, American Legion Hall
20 Effingham, Extension Center

Authors

Department of Dairy Science, University of Illinois at Urbana-Champaign, except as noted

MICHAEL R. BELL, research assistant, physiology

JIMMY H. CLARK, professor, nutrition

BRIAN A. CROOKER, research assistant, nutrition

CARL L. DAVIS, professor, nutrition

W.R. (REG) GOMES, professor, reproductive physiology and department head

CHARLES N. GRAVES, associate professor, reproductive physiology

MICHAEL GROSSMAN, associate professor, breeding and genetics

RIC R. GRUMMER, research assistant, nutrition

STANLEY F. HUELS, research assistant, physiology

WALTER L. HURLEY, assistant professor, lactation

MICHAEL F. HUTJENS, professor, Extension dairyman

EDWIN H. JASTER, assistant professor, management

J. ROBERT LODGE, professor, reproductive physiology

GENE C. McCOY, associate dairy scientist, management

MICHAEL R. MURPHY, assistant professor, nutrition

SUWAT RATTANARONCHART, research assistant, breeding and genetics

KATHLEEN A. ROONEY, research assistant, breeding and genetics

ROGER D. SHANKS, assistant professor, breeding and genetics

CHARLES R. STAPLES, research associate, nutrition

STANLEY T. SMITH, area dairy adviser, Dixon, Illinois

JOHN L. VICINI, research assistant, nutrition

HOLLY WHETSTONE, research assistant, nutrition

Contents

1983 THEME: ECONOMICS AND EFFICIENCY

UNIVERSITY OF ILLINOIS RESEARCH REPORTS

The Department of Dairy Science

W.R. (REG) GOMES

As part of our continuing effort to provide members of the dairy industry with current and useful information, we in the Department of Dairy Science are pleased to present the *1983 Illinois Dairy Report*. In conjunction with our winter Dairy Days program, this publication is designed to inform the dairy farm family of current changes in the industry and of any research that may lead to further changes. Together with the *Illinois-Iowa Dairy Handbook* and the *Illinois Dairy Digest*, it also helps supplement educational efforts such as the Illinois-Indiana Dairy Management Clinic and the IMPA Dairy Seminar. At a time when the dairy farmer faces smaller margins of profit and less room for error, we are convinced that an aggressive program of research, teaching, and dissemination of current information is essential to maintain a strong industry.

During 1982 we were gratified with the response to our dairy reproduction workshop and our two modernization workshops in Illinois. The efforts of our Dairy Science Club students at the Illinois State Fair—including the highly successful "Milk-a-Cow" exhibit—reaffirmed the enthusiasm of our young people for the industry.

Our teaching program in Urbana for both undergraduate and graduate students is changing to meet the needs of increasing numbers of bright, dedicated students, and our research program continues to produce important information for today and the future. These services are made possible through the efforts of an outstanding department faculty (listed below), who are guided in part by the experience of our industry advisory committee. The committee members for 1982-83 are Carl Baumann of Highland, Myron Erdman of Chenoa, Ray Hess of Hampshire, William Lenschow of Sycamore, Kevin Lyons of Granville, Roger Marcoot of Greenville, Melvin Schweizer of Nokomis, and Richard Vetter of Arlington Heights.

The faculty of the department, the members of the advisory committee, and I welcome your comments, suggestions, and questions. We appreciate your interest in the 1983 Dairy Days program and hope that you will find it useful.

DEPARTMENT OF DAIRY SCIENCE

Faculty members	Specialization
Marvin P. Bryant, professor	Ruminant microbiology
Jimmy H. Clark, professor	Dairy cattle nutrition
Carl L. Davis, professor	Dairy cattle nutrition
Charles N. Graves, associate professor	Reproductive physiology
W.R. (Reg) Gomes, professor and department head	Reproductive physiology
Michael Grossman, associate professor	Dairy breeding and genetics
Gerhard W. Harpestad, associate professor	Extension dairyman
Robert B. Hespell, associate professor	Ruminant microbiology
Walter L. Hurley, assistant professor	Lactation endocrinology
Michael F. Hutjens, professor	Extension dairyman
Edwin H. Jaster, assistant professor	Dairy cattle management
Ralph V. Johnson, associate professor	Extension dairyman
Bruce L. Larson, professor	Biochemistry and lactation
J. Robert Lodge, professor	Reproductive physiology
Gene C. McCoy, farm manager	Dairy cattle management
Michael R. Murphy, assistant professor	Dairy cattle nutrition
James L. Robinson, associate professor	Biochemistry
Roger D. Shanks, assistant professor	Dairy breeding and genetics
Sidney L. Spahr, professor	Dairy cattle management

Energy: First Limiting Nutrient

MICHAEL F. HUTJENS

Today's increasing gas prices, high power bills, and ads about weight-watchers are constant reminders of our present energy concerns. The energy-related terms *fat cow syndrome*, *ketosis*, and *low milk fat test* are also common in the dairy farmer's vocabulary. The cow's energy intake is limited by a minimum forage and fiber requirement, by how much feed she can consume, and by the limited number of available high-energy feed choices. (By contrast, protein shortages can be corrected by adding soybean meal, and phosphorus shortages can be corrected by adding monosodium phosphate.) With these limitations, and with the fact that milk production is increasing 1 to 3 percent annually, herd outputs are averaging over 20,000 pounds of milk per cow per year, and some cows are producing over 30,000 pounds of milk per year, it is clear that energy is the most limiting nutrient for most high-producing cows. Solving the energy challenge would improve milk yield, reproductive performance, and herd health.

THE ENERGY-LACTATION CURVE

The amount of energy required by the lactating cow varies tremendously depending on the amount of milk produced and the stage of lactation (Figure 1). On every dairy farm, cows can be divided into five groups according to their energy status and needs (first 70 days postpartum, 70 to 200 days postpartum, 200 days postpartum to drying off, and two groups of dry cows). Milk yield typically peaks at 4 to 6 weeks after calving (2 to 4 weeks if the milk yield is adjusted for higher fat tests) and declines 8 to 10 percent per month during the remainder of the lactation period. To compound this energy demand, dry matter intake lags behind by 6 weeks, peaking in weeks 10 to 12 after calving. Cows lose body weight in an attempt to partially meet this energy demand. For a high-producing cow to produce an additional 7 pounds of milk (3.5 percent fat), she must either mobilize 1 pound of body weight or consume an additional 2 to 3 pounds of grain. Cows in good condition lose 200 to 300 pounds of body weight, which would support 1,500 to 2,000 pounds of milk in early lactation.

Following are some strategies for helping the cow meet her energy needs during the first 10 weeks postpartum.

1. Provide extra protein and minerals to help the cow use body fat as an energy resource.
2. Control body weight loss to avoid ketosis. Niacin, a B vitamin, may be beneficial when supplemented at 6 grams per cow per day from 7 days before calving to 10 weeks after calving.

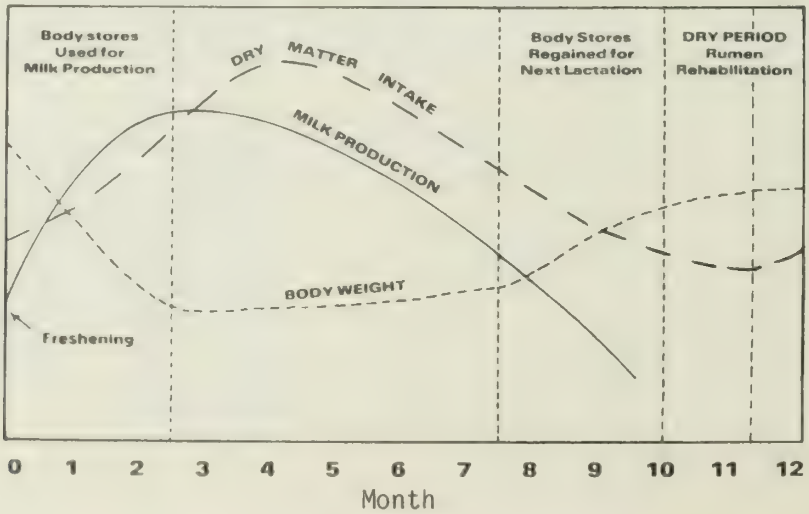


Figure 1. The gestation-lactation cycle.

3. Encourage maximum dry matter intake by feeding top-quality feeds, by feeding frequently, and by providing buffers to stabilize rumen and dietary changes.

4. Consider adding fat to increase energy concentration and maintain fat test.

THE ROLE OF FORAGE QUALITY

Forages supply 40 to 100 percent of the total amount of dry matter in the dairy ration. Thus the quality of forage dictates the energy level of the diet (Table 1). Added grain can increase energy levels but cannot totally compensate for poor-quality forage. Forage must therefore be tested for its energy level. Digestibility tests measure feed intake, fecal losses, heat-generated losses, urine losses, and productive activities. For immediate practical use, however, these tests are expensive and time-consuming, and forage energy values can instead be estimated by analyzing the fiber level in the feed.

Table 1. Variation in Amount of Potential Milk (Based on Energy) According to Forage Type and Forage-to-Grain Ratio (Virginia)

	Forage-to-grain ratio			
Forage	100	80:20	60:40	40:60
	pounds of milk			
Alfalfa, prebloom	43	52	61	72
Alfalfa, mature	14	26	41	57
Corn silage	41	52	63	72

Two fiber analyses are commercially available. The *crude fiber (CF) analysis* provides a measure of the indigestible portion of the feed. A sample of feed is digested with a weak acid solution, which is then followed by a base solution that removes proteins, sugars, and starches. The residue is called crude fiber. However, a portion of the crude fiber fraction (hemicellulose) can be digested when energy values are determined in this manner. Furthermore, the highly indigestible lignin is removed by the alkali treatment and is not measured. The *acid detergent fiber (ADF) analysis* measures the amount of cellulose, lignin, and acid-insoluble ash in the feed. This procedure uses detergents to solubilize hemicellulose and cell contents that are digestible.

The results of these two tests can be interpreted using the following energy prediction equations. Be sure that all fiber values are expressed on a 100 percent dry matter basis before calculating energy values. (TDN = total digestible nutrients expressed as a percentage; NE_L = net energy lactation expressed as megacalories per pound of dry matter.)

Legumes: $TDN(\%) = 85.23 - (0.65 \times ADF\%)$

$NE_L(Mcal/lb) = 1.044 - (0.0123 \times ADF\%)$

$TDN(\%) = 78.7 - (CF \times 0.8)$

Grasses: $TDN(\%) = 92.51 - (0.8 \times ADF\%)$

$NE_L(Mcal/lb) = 1.085 - (0.015 \times ADF\%)$

$TDN(\%) = 78.7 - (CF \times 0.8)$

Corn silage: $TDN(\%) = 87.84 - (0.7 \times ADF\%)$

$NE_L(Mcal/lb) = 1.044 - (0.0131 \times ADF\%)$

$TDN(\%) = 72.1 - (CF \times 0.34)$

FORAGE-TO-GRAIN RATIO

A quick review of feed tables would indicate that you should feed more grain to increase energy intake. However, in addition to the requirements for fiber, physical bulk and size are also needed to maintain rumen digestibility. Furthermore, digestibility decreases as the level of feeding increases (Figure 2)—by 4 percentage units for each multiple of maintenance fed. A cow fed at three times maintenance produces 70 to 80 pounds of milk. Excessive levels of grain can actually result in less available energy for the cow. In a Wisconsin study, the highest grain ration was not the highest energy ration (Table 2).

Table 2. Calculated and Measured TDN Values for Various Forage-to-Grain Ratios

Forage-to-grain ratio	Calculated TDN	Measured TDN
	percent	
85:15	57.3	64.2
65:35	63.1	67.7
50:50	67.5	64.4

Level of intake, requirements for rumen fermentation, and differences in volatile fatty acid utilization influence the amount of energy that can be obtained from a ration. Calculated ration TDN values of 70 percent are near the maximum. Following are some strategies for providing optimal available energy to the cow:

1. Mix grain and forages together to increase digestibility and utilization of feed nutrients (total-mix ration concept).
2. Base forage-to-grain ratios on forage quality and type (see Table 3).
3. Be careful when adding grain to the ration. At maximum feed intake, 1 pound of additional grain dry matter replaces 0.5 pound of forage dry matter and lowers fiber intake.
4. Maintain 6½ to 7 pounds of crude fiber or 8 to 8½ pounds of ADF in the total ration dry matter.
5. Carefully manage grain levels that are over 30 pounds of dry matter per cow per day: feed several times per day, add a fiber source to the grain mix, and monitor the physical form of the total ration.
6. Provide 5 pounds of long fiber (over 1 inch long) to maintain rumination and meet fiber length requirements.
7. Add 0.25 pound of sodium bicarbonate in early lactation. This buffer may stabilize rumen digestion and stimulate dry matter intake.

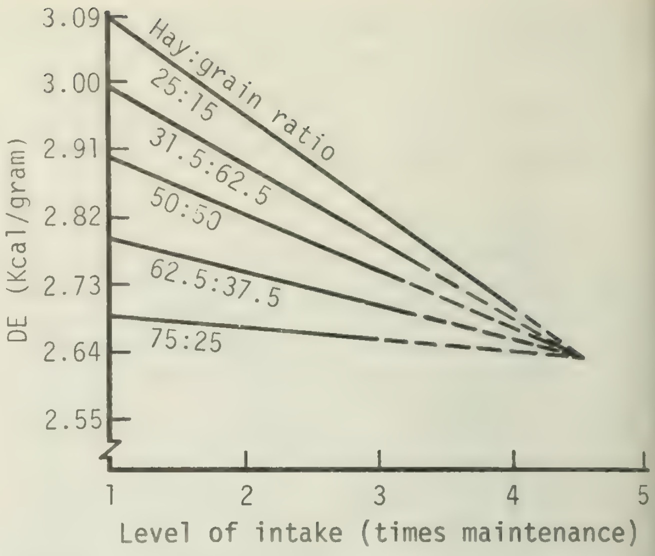


Figure 2. Depression of digestible energy (DE) in dairy cattle according to hay-to-grain ratio and level of feed intake (Wisconsin).

Table 3. Variations in Forage-to-Grain Ratios According to Forage Type, Quality, and Milk Yield (Illinois)

	Forage-to-grain ratio	
Forage type	High milk group	Low milk group
Corn silage	50:50	85:15
Legume (high quality)	45:55	75:25
Legume (low quality)	35:65	60:40

DRY MATTER INTAKE

The dairy producer's main goal should be to maximize dry matter intake early in lactation. Dairy producers often feed too much grain. Remember that you cannot overfeed or "burn out" a cow if the ration is balanced for fiber, forage, and energy. Ascertain your herd's dry matter intake so that you can provide the desired level of nutrients. If the dry matter intake in your herd or group of cows is lower than that shown in Table 4, try to find the reason (limited amount of feed, infrequent feeding, low forage quality, limited bunk space, high moisture levels in the ration, or incorrect forage-to-grain ratio). Cows have an absolute nutrient requirement (pounds of protein or grams of calcium), not a percentage requirement. With accurate dry matter intake values, ration formulation is an easy job.

Recent Illinois research indicates that excessively wet rations have lower dry matter intake potential. Rations with over 50 percent moisture may result in lower feed intake. Cornell workers have suggested that dry matter intake drops by 0.2 pound per 100 pounds of body weight for every 10-unit increase in moisture. For example, for a 1,400-pound cow, a ration shifting from 50 to 60 percent moisture could result in 2.8 pounds less dry matter consumed. This amount could support 5 to 6 additional pounds of milk on an energy basis.

Table 4. Suggested Maximum Dry Matter Intake as Related to Body Weight and Milk Yield, Expressed as Percentage of Body Weight (1978 NRC)

	Dry matter intake for various body weights					
Yield of 4% FCM[a] (lb)	800 lb	1,000 lb	1,200 lb	1,400 lb	1,600 lb	1,800 lb
			percent of body weight			
20	2.5	2.4	2.3	2.2	2.1	2.0
40	3.1	2.8	2.7	2.6	2.4	2.3
60	3.6	3.3	3.2	3.0	2.8	2.7
80	4.1	3.8	3.6	3.4	3.2	3.1
100	---	4.1	3.9	3.7	3.5	3.4

[a]Fat-corrected milk.

ADDING FAT TO THE RATION

Since high-producing cows require higher levels of energy, high levels of grain and starch can result in rumen acidosis and off-feed disorders. Fat can be substituted for carbohydrates as an energy resource in dairy feeds. However, excessive levels of fat depress fiber digestibility, influence microbial populations in the rumen, and shift rumen acetate and propionate levels and rumen pH. Thus, the level and type of fat or oil in the ration must be carefully considered. One pound of added fat per cow per day is near the maximum. Higher levels can be fed if fiber digestibility is maintained and adequate amounts of dietary calcium are fed (extra fat or oil can tie up the calcium in a soaplike product). Following are some available sources of added fat.

1. Raw soybeans (cracked, ground, or rolled) can be fed at the rate of 3 to 4 pounds per cow per day. Do not feed raw beans to young calves because trypsin inhibitor, an enzyme, reduces protein digestion. Do not mix raw beans with feeds that contain urea because the enzyme urease produces an ammonia odor in the feed.
2. Roasted or extruded soybeans can be fed at the rate of 5 to 7 pounds per day. The heated soybean protein is lower in rumen degradability (an advantage for high-producing cows), and problems with rancidity, urease, or trypsin inhibitor are reduced.
3. Six to 8 pounds of whole cottonseeds will increase energy intake. Higher levels can cause a problem with the level of gossypol (a toxin).
4. Sunflower seeds can be fed at the rate of 4 to 5 pounds per cow per day.
5. Vegetable oil (such as soybean oil) can be added at the rate of ½ to 1 pound per cow per day, or 2 to 4 percent oil can be added to the dry grain mixture. The oil will also reduce dustiness and minimize separation of fines.
6. Several dry products are commercially available that contain 40 to 60 percent fat. These products are usually animal fat sources and are used in milk replacers, but they could be fed to adult cattle.

Different kinds of fat can result in different production and health responses. Animal sources (lard or tallow) are saturated fats and have less effect on rumen and fiber digestion. Unsaturated fats or oils (soybean, corn, or fish oil) can have detrimental effects on rumen digestion and fat test but usually are more economical. Carefully evaluate the cost per unit of energy, the feed intake, and the anticipated milk or fat response before deciding which kind of fat to add.

ENERGY IN THE DRY COW PROGRAM

A major problem occurs when one attempts to solve the energy problem in high-producing herds by overconditioning cows during late lactation and the dry period. When energy is not controlled during these periods, cows become obese and are more susceptible to metabolic disorders. The internal organ most severely affected by excessive energy is the liver. Michigan State researchers report that in healthy cows, fat deposits begin to occur in the liver 1 to 2 weeks before calving and continue to build up until 2 weeks after calving. Cows that can clear or mobilize their liver fat will have a healthy and productive lactation. Obese

cows will go off feed earlier before calving, will go off feed to a greater degree, and will be slower to come back on feed and maximize dry matter intake. Following are some strategies for minimizing liver fat problems:

1. Replace body weight lost in early lactation before the cow goes dry. Body weight is replaced more efficiently when the cow is milking (61 percent) than when she is dry (48 percent).
2. Put dry cows into a separate group. Feed only enough grain to meet maintenance and pregnancy needs. Consider making a second close-up (within 2 weeks of calving) dry cow group and ration.
3. Monitor body weight gain during the dry period (the fetus, membranes, and fluids represent roughly 150 pounds of that weight gain).
4. Minimize ration changes within three days of calving, since most cows go off feed at this time.
5. Control stress factors such as mastitis, metritis, and metabolic disorders.
6. Consider supplementing niacin to overconditioned dry cows to control fat mobilization and minimize ketosis.

Managing Your Milking System

EDWIN H. JASTER

As recently as 30 years ago, only 51 percent of our cows were machine-milked. Since then, our understanding of milking management, the effects of overmilking, automation in the parlor, teat dips, and herd mastitis control programs has changed significantly. Today, we know that to achieve high levels of milk production, the dairy producer must use good milking techniques and machines that will milk cows efficiently and without discomfort. The decisions made in a particular chore activity or management problem effecting milking in the barn or parlor will determine the success of a milk harvest.

The stanchion barn is still the most widely used milking facility, and most herd owners with more than 40 cows in a stanchion barn have installed a pipeline milking system. These barns allow for individual cow handling and observation but usually have lower milking rates than parlors. The University of Minnesota recently established standards for dairy managers with stanchion barns. Those standards were subsequently compared to the efficiencies obtained in alternative parlor types. The milking routine in 14 Minnesota stanchion barn herds and 4 California system (flat barn) herds was studied in detail. The results were compared to similar milking chore activity data collected previously on side-opening and herringbone parlors in Nebraska. Throughputs (cows milked per hour) obtained in rotary and polygon parlors in Michigan and Arizona were also summarized.

Typical milking management in pipeline stanchion barns varies considerably in different areas of the country. In the Midwest, cows are fed, housed, and milked in stanchions. Western dairymen also milk in stanchion (flat) barns, but they house the cows in open-lot corrals between milkings. Cows are switched through the barn in groups for milking.

The milking process in western barns typically utilizes more units than midwestern barns, and milk yield per man-hour of labor usually exceeds the midwestern counterpart (Table 1). Factors influencing these differences include: group udder washes before cows enter the barn; high-capacity low-line milking systems with a milking unit for each pair of cow stalls; fewer problems with unit drop-off; and less dependence on machine stripping. Level of production is another important variable influencing barn efficiency (Table 1). Increased production per cow usually results in more milk per hour of labor but less throughput.

Table 1. Milking Management Data for Pipeline Stanchion Barns (Minnesota)

Description	Milk yield per milking (lb) 21[a]	29[b]	42[c]
Units per operator	3.0	4.0	4.0
Cows per man-hour	35.0	28.6	29.4
Yield per man-hour (lb)	699.0	818.0	1,231.0
Unit-on time (min)	4.8	6.3	7.2
Average flow rate (lb/min)	4.3	4.6	5.8

[a]Data from 14 Minnesota herds.
[b]Data from 4 California herds.
[c]Data from 1 California herd.

THE MILKING MACHINE OPERATOR

When the operator is using two or more milking units, he must make a decision each time he completes a particular chore activity. He can either proceed with the next logical step in the milking routine on that same cow, or he can complete some task on another cow. Milking machine operators vary tremendously, both in how they choose the next chore activity and in how much time they spend completing a particular activity. They are characterized into three general types (Table 2): the stripper, the speeder, and the star of the show.

The stripper is the operator that feels he must obtain the very last drop of milk from each quarter. He loses track of time and may average from 0.75 to 2 minutes stripping each cow. We recommend that no more than 20 seconds be spent machine-stripping. (The sleeper differs from the stripper only in how he wastes time. He may simply move slowly and spend too much time completing each task, or he may have long periods of idle time in which he accomplishes no productive work.)

The speeder is always in a hurry; he rushes to the next job before he does the job at hand properly. This operator frequently fails to obtain a complete milk letdown before attaching the unit, tends to jerk off the unit when he finishes milking without first

Table 2. Variations in Time Spent at a Particular Chore Activity[a]

Chore activity	Type of operator: The stripper[b]	The speeder	The star of the show
Before milking (min/cow)			
Preparing the udder	0.41	0.17	0.40
During milking (min/cow)			
Applying the unit	0.21	0.21	0.23
Adjusting the unit	0.09	0.08	---
Checking and stripping the udder	0.87	0.05	0.36
Removing the unit	0.32	0.20	0.20
Other (min/cow)			
Dipping teats	0.20	---	0.20
Moving equipment	0.14	0.04	0.03
Changing cows	---	---	---
Other	0.12	0.01	---
Operator idle time (min/cow)	0.40	0.20	0.25
TOTAL MINUTES PER COW	2.76	0.96	1.67
Cows per man-hour	21.70	62.50	35.90

[a]This data is typical for the milking machine operations that use 3 units in a pipeline stanchion barn where the cows are already in their stalls.
[b]The sleeper is similar to the stripper except that he will spend less time machine stripping and more time being idle or unproductive.

shutting off the vacuum, will probably make a haphazard pass at dipping teats and may not even cover the teat end with the intended disinfectant, and will find his cows excitable and reluctant to enter the milking stall.

The star of the show is the operator who is well organized, observant, alert, and quiet and whose motions are smooth and fluid. He is concerned about his cows and at the same time strives for maximum efficiency (high milk yield per man-hour).

All machine operators should have frequent, but relatively short, idle-time periods when milking cows. These periods help insure their availability when cows need attention and break the monotony and tedious work associated with milking cows. It has been observed that excellent operators are idle about 9 minutes out of every hour (15 seconds per cow when milking 36 cows an hour).

OVERMILKING AND UDDER HEALTH

Dairy producers are concerned about the harmful effects of overmilking or fixed-time milking on udder health. Some of the potential hazards are direct injury to the teat and udder tissue, which would leave the teat more susceptible to invasions by mastitis-causing organisms; transfer of bacteria from infected to uninfected quarters at the time when most milk flow has stopped; and lengthening of the milking period, with increased risk of mastitis.

Research workers at Cornell University recently reported on the effect of overmilking on udder health. Various milking regimens were studied. The two discussed here are 1) control-cluster removal as milk flow ceases and 2) removal of overmilked units after 12 minutes of milking. Twenty cows were allotted to each regimen. They were assigned to groups 3 to 21 days after freshening and were milked for 27 weeks after calving. All cows were milked in a double-ten herringbone parlor at 15 inches of mercury, with 60 pulsations per minute and a 70:30 pulsation ratio. The milking routine included dampening the teats with a hose, drying the udders with paper towels, checking for abnormal milk, and attaching milker units. The vacuum supply was interrupted before the units were removed, and cow teats were *not* dipped. Milk samples for bacteriological determination were collected from individual cows 1 week before the project began and at 3-week intervals thereafter. A quarter was considered infected when two consecutive samples contained the same organisms.

The new infection rates are summarized by 3-week intervals in Table 3. The total new infection rate for both groups was 44 infections in 40 cows in 27 weeks. However, 68 percent (30/44) of the new infections resulted from overmilking. Table 3 also gives the number of clinical cases of mastitis. Twenty-three percent of quarters with new infections developed clinical mastitis. Overmilked cows required 7 treatments, as compared to 3 treatments for cows with normal milking time. The percentage of new infections becoming clinical was

Table 3. New and Clinical Mastitis Infections in Quarters of 40 Cows Milked by One of Two Milking Regimens for 27 Weeks

Treatment	Weeks on trial 0-3	4-6	7-9	10-12	13-15	16-18	19-21	22-24	25-27
Control									
New infections	2	1	2	1	4	2	2	0	14
Clinical mastitis	0	1	0	0	1	0	1	0	3
Overmilked (12 minutes)									
New infections	1	2	2	8	8	4	3	2	30
Clinical mastitis	0	1	0	1	2	0	2	1	7
Total									
New infections									44
Clinical mastitis									10

similar for both groups, and overmilking increased the number of new infections. The negative effect of overmilking is likely associated with the transfer of mastitis bacteria from infected to noninfected quarters during the time of little or no milk flow. The Cornell University researchers revealed that it is not always found on all dairy farms where overmilking exists. In dairy herds with few infected quarters, the reservoir for multiple infections is absent and no negative effect is apparent. In herds with higher percentages of infected cows, the reservoir is present and overmilking therefore causes an increase in new infections and clinical mastitis cases.

An example of the interrelationship between number of units used, operator efficiency, and milk flow rate (determined by the milking system and the cow's ability) is illustrated in Table 4. Once the "cow cycle time" (the time between attaching a unit on one cow to attaching the same unit on another cow) is established and the number of milking units used per man is known, one can them use Figure 1 to determine the production necessary (yield per milking) to avoid extreme overmilking.

Similarly, if both operator time per unit and average yield per milking are known, then the recommended number of units used per man can be obtained from Figure 1. Researchers at Michigan and Arizona have published typical throughputs obtained in the various types of milking facilities (Table 5). This data was used to calculate the minutes required per cow to complete all chore activities.

BACKFLUSHING: THE NEXT STEP IN AUTOMATION

Nearly all types of mastitis originate at milking time. Milking machines, milking techniques, and the level of sanitation in the milking parlor directly affect the incidence of mastitis in a dairy herd. Dairy managers continue to turn to automated milking equipment as an answer to labor problems and as a step toward greater efficiency. Frequently, however, the move to automation give rise to other problems. Garget or mild forms of mastitis go unnoticed, teat-dipping is handled ineffectively, and equipment malfunctions may go undetected. Small milking imperfections can lead to a rapid increase in mastitis infections when the environment has become contaminated with disease-causing bacteria.

Bacterial cultures of milking machine liners have consistently shown high concentrations of organisms. Despite teat-dipping and dry-cow therapy, dairy herds have sustained epidemics of mastitis caused by staphylococcus, mycoplasma, *Streptococcus agalactiae*, and coliforms. Experience with these herds has demonstrated the value of segregating infected cows and of disinfecting units between cows.

The need for better sanitation at milking time is obvious. Bacterial cultures of liners taken before and after backflushing show that flushing dramatically reduces contamination. Backflushing the milk hose, claw, and liners is more effective than flushing liners alone. The claw can also harbor pathogenic (disease-causing) bacteria. In response to the need for better sanitation, several manufacturers are developing equipment to mechanize sanitation. Following are examples of several systems.

Unit backflush system; single-phase, hand-operated. Between cows, the milk hose of each unit is removed from the milk line and attached to a separate backflush line containing a 25-ppm iodine solution. The entire unit is backflushed for 5 seconds with 4 liters of the solution. Each unit is left hanging for 5 minutes before it is reattached to the milk line and the new cow; this pause allows adequate time for draining the unit and for bactericidal action of the iodine.

Unit backflush system; 4 phases, automatic. Two seconds after the vacuum is shut off and the unit is removed from the cow, phase I automatically activates the unit with 3 liters of plain water to backflush. Immediately, phase II flushes the unit with 2 liters of a 25-ppm iodine solution. After a waiting period of 30 to 45 seconds to allow adequate contact for bactericidal action, phase III flushes the unit with 3 liters of clear water. In phase IV, the entire unit is air dried with a separate vacuum line just before the unit is placed on the next cow.

Table 4. Relationship between Number of Units, Operator Efficiency, and Milk Flow Rate

Description	Operator efficiency: 4 units/ excellent operator	3 units/ excellent operator	3 units/ poor operator
Operator time per unit (min)	1.7	1.7	2.5
Cow cycle time (min)	6.8	5.1	7.5
Unit idle time (min)[a]	0.5	0.5	0.5
Actual milking time (min)	6.3	4.6	7.0
Assumed flow rate (lb/min)[b]	5.0	5.0	5.0
Yield per milking, no excessive over-milking (lb)	31.5	23.0	35.0
Approximate yearly production required to prevent overmilking (lb)	19,000	14,000	21,700

[a]Unit idle time (interval between removal and application to subsequent cow) is assumed to average 0.5 minute.

[b]A flow rate of at least 5 pounds per minute was assumed to be ideal and realistic.

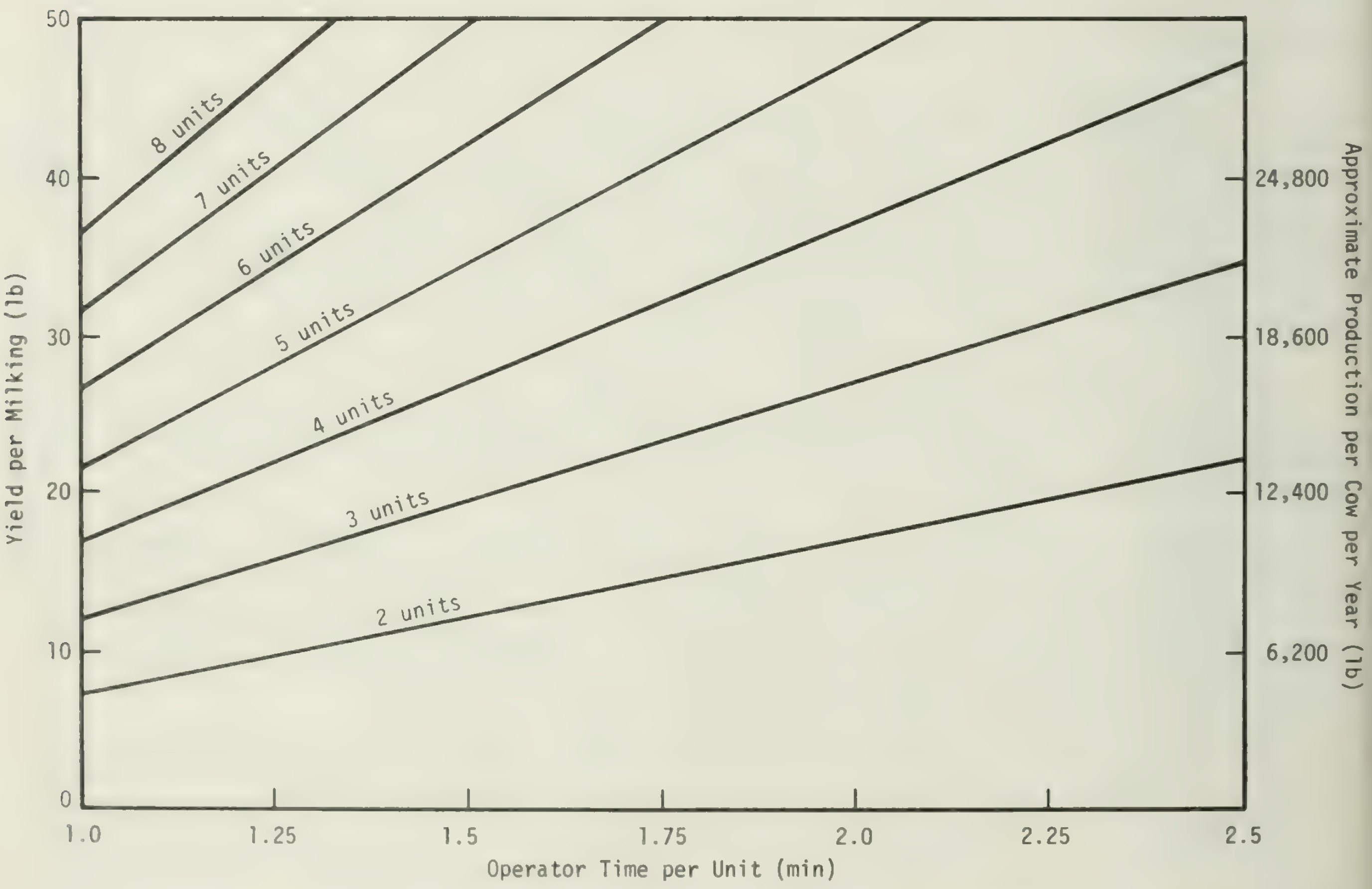


Figure 1. Production necessary to avoid overmilking.

Table 5. Relationship of Milking Facility to Chore Activity Time (Michigan and Arizona)

Type of facility	Number of installations	Number of cows per man-hour	Chore activity time per cow (min)
Stanchion, pipeline	18	34	1.76
Herringbone, standard	42	37	1.62
Side-opening, standard	17	42	1.43
Rotary	19	51	1.18
Side-opening, mechanized	8	54	1.11
Herringbone, mechanized	7	75	0.80
Polygon	6	78	0.77
Trigon 12	NA	70	0.86

Unit backflush system; 3 phases, automatic or semiautomatic. During the flushing phase, the milk hose moves automatically from milk to positive air, then to a sanitizing flush with 25 ppm iodine, then back to air, and then back to milk. The entire cycle takes about 1 minute.

Electronically controlled 4-phase system. This system allows each step—clear-water rinse, iodine flush, clear-water rinse, and forced-air drying—to be adjusted.

Teat washer primer; hand-held. This hand-held unit is activated by pressing it against the udder; it cleans only the teats and does not wet adjacent udder surfaces. An iodine solution is forced under 60-psi pressure to foam-flush the teat. Dilutions of 25-, 30-, 100-, and 200-ppm iodine have been used in this system, which has been tested for both premilking and postmilking teat sanitizing. Teats are flushed and then dried with a single paper towel before the milking machine is placed on the cow. This method also appears to increase milk letdown before milking.

Teat sprayer; postmilking, hand-held. This recently developed air-pressure unit uses the same basic hand-held unit as the preceding system. Instead of a dilute iodine/water solution, a fine spray of concentrated (10,000-ppm) iodine dip is forced on the teat.

The question often arises whether backflushing with clear water is as beneficial as flushing with sanitizers. Research results in the United States and England indicate that water alone leaves sufficient numbers of pathogens on liners and teat surfaces to transfer infection from cow to cow. Low levels of iodine sanitizers have proven effective in sanitizing liners (Table 6).

TEAT DIPS AND MASTITIS CONTROL

Disinfecting teat ends after milking to help prevent mastitis was first considered in 1916. The practice was not widely accepted for many years because the germicides used were only marginally effective. In the mid-1960s the use of teat dips as part of a total hygiene program to prevent new intramammary infections was investigated in field trials. In these trials, individual paper towels were used for udder washing, operators wore gloves that they disinfected between milkings, teat cups were disinfected, and teats were dipped in a disinfectant solution after milking. These methods were effective but proved to be too time-consuming to gain widespread acceptance by dairy managers. Dipping teats alone reduced the number of new infections by 50 percent for most gram-positive organisms (staphylococcus and streptococcus).

Table 6. Relative Sanitizing Efficiency of Water and Iodine Solutions

Product	Reduction of bacteria: Staphylococcus	Coliform	Total
	percent		
Water, 68°F	36	56	77
Iodine, 25 ppm	86	90	90
Iodine, 80 ppm	89	94	94

Most of the early work in the 1960s with teat disinfectants used solutions of 4 percent sodium hypochloride or 1 percent iodophor compounds. As the practice of teat-dipping increased, so did the number and types of products. The types of products that have been used

are listed in Table 7. An acrylic latex preparation has recently been developed that serves as a mechanical barrier or teat cover to reduce gram-negative infections (coliforms).

Teat-end irritation can be a problem when a teat disinfectant is used, and emollient products such as glycerine or lanolin may reduce this irritation. These emollients are most effective in concentrations of 2 to 4 percent. The method of applying the teat dip may also affect the efficacy of this practice. Spraying teat ends has reduced the rate of new intramammary infections by 45 percent. However, if the milker is in a hurry, he may spray only part of the teat. Below are management tips on using teat dips:

Table 7. Compounds Used for Teat-End Disinfection (Minnesota)

Compound	Concentration (percent)
Iodophors	0.25 to 1
Polyvinylpyrrlidone iodine	0.5 to 1
Hypochlorite	0.2
Iodine in oil	0.5 to 1
Chlorhexidine	0.5
Chlorine dioxide	0.04 to 0.2
Na dichloro-S-triazene-trione	0.3 to 1
Hexachlorophene	1
Diaphen	1
Cetylpridinium chloride	0.1 to 0.2
Ammonium chloride	0.5
8-Hydroxyquinoline sulfate	0.1

1. For maximum efficacy and reduced teat irritation, read the directions on the containers carefully.
2. Iodophor products with low pH tend to irritate teats; additions of emollients reduce the problem.
3. Teat dips that have been frozen may irritate teat ends.
4. Watch for teat-end lesions when beginning teat dipping or changing types of dips, and discontinue use when irritation is noticed.

DRY COW TREATMENT

The best time to treat most subclinical udder infections is at drying off. The cure rate is higher than when the infection is treated during lactation, the incidence of new infections during the dry period is reduced, damaged tissue may be regenerated before freshening, clinical mastitis at freshening is reduced, and otherwise salable milk is not contaminated with drug residues.

The effectiveness of the dry cow treatment is improved by the use of slow-release products that maintain therapeutic levels of antibiotics for long periods in the dry udder. Products designed for lactating animals should not be used to treat cows at drying off. The preferred time to treat is after the final milking of the lactation period.

When the dry cow treatment is practiced routinely as part of a mastitis control program, the dairy producer or veterinarian must decide which quarters should be treated. Treating all quarters of all cows insures that all infected quarters are reached, is more effective than selective treatment in preventing new dry period infections, and does not require laboratory or screening procedures. This method is recommended for herds that are known to have a high level of infection—that is, over 500,000 somatic cells per milliliter (ml).

When the herd level has been reduced or when herds are not heavily infected initially, selective dry cow treatment may be desirable. If bacteriological diagnosis is available, all quarters found to be infected should be treated. Other criteria that may be used include a history of clinical mastitis during the preceding lactation or the presence of large numbers of somatic cells as determined by screening tests. Selective treatment based on these two latter criteria may fail to reach 20 to 40 percent of the infected quarters. Moreover, quarters not treated at drying off are more likely to become infected before calving than treated quarters.

SOMATIC CELL COUNT (SCC) PROGRAMS AND MASTITIS CONTROL

Cell counting is of great benefit in monitoring the herd situation and in making dairy managers aware of a herd problem early. The best way to use the individual average cell

counts is to compare the counts of all cows of similar age and stage of lactation. Any cow whose average somatic cell count is significantly higher than those of comparable cows should have each quarter examined by California Mastitis Tests (CMT) and cultures.

Somatic cell counts on an individual cow basis can be a very useful tool in a mastitis control program, but they must be interpreted correctly. It is even more important to determine what factors are causing high counts and to eliminate them. Treatment without correction is a waste of time and money. High-producing herds should have consistently 75 percent or more of their cows with cell counts below 500,000. First-lactation heifers should have counts of 200,000 or less. If the average somatic cell count or the bulk tank samples is over 500,000, the dairy producer is losing money through lost milk production.

Poor cow sanitation, faulty equipment, and poor milking equipment can all lead to high cell counts and lower milk production. Poor cow sanitation is the most frequent herd problem encountered. Counts in problem herds are likely to go up in May and drop in November and are often associated with confining cows to lots that turn to dirt or manure. Equipment that has been improperly installed, maintained, or used can lead to high cell counts. Sudden increases in herd cell counts have been observed with faulty teat cup liners, flooded milk lines, and teat cup vacuum fluctuations. Observations indicate that high milk lines may cause higher cell counts because they cause higher vacuum fluctuations.

A regular and systematic cell count used in a mastitis control program, including correct milking procedures, should help dairy managers reduce losses due to mastitis. Each dairy manager should plan an individual program in consultation with his veterinarian, milking equipment dealer, and dairy field representative.

INTERPRETING INDIVIDUAL COW SOMATIC CELL COUNTS

To interpret and use the SCC report, one must have a basic understanding of what various cell counts indicate. Monthly cell counts will do nothing to control mastitis unless the dairy manager is willing to take action based on the results. Following are some points to remember when evaluating somatic cell counts.

Tests under 500,000. Cows with cell counts below 500,000 can generally be considered uninfected, although some infected cows may occasionally dip below this level.

First-calf heifers normally freshen without mastitis and with very low cell counts (100,000 to 350,000 cells). The normal cell count gradually increases as the cow ages and is exposed to injury and infection. Up to about 750,000 may be considered normal for older cows. Cows in late lactation will normally have higher cell counts because the cells are more concentrated when fewer pounds of milk are given.

500,000 to 750,000. Most cows with cell counts between 500,000 and 750,000 are infected. This level indicates udder irritation with some loss of production. CMTs should be conducted on milk from cows that test over 500,000 cells per milliliter to determine which individual quarters have an inflammation. In older cows, counts up to 750,000 can be normal.

750,000 and higher. Cows with counts of over 750,000 may have mastitis. Even though they usually have a steady increase in cell count, however, they may not show clinical mastitis. From 70 to 80 percent of infected quarters do not show symptoms other than high cell counts. For every quarter that shows clinical signs of mastitis, there are 10 to 20 infected quarters that show no visible symptoms.

USING SOMATIC CELL COUNT INFORMATION

Cows testing over 500,000 cells per milliliter in early lactation whose production exceeds 50 pounds of milk should be brought to the attention of the veterinarian. Returns from treating these cows during lactation will generally offset treatment costs (including withheld milk). Milk should be cultured to determine the type of infection present. Cows in mid- to late lactation with counts of 500,000 should not be treated unless abnormal milk is detected; dry cow treatment is recommended for those cows. Again, consulting with the veterinarian and taking a milk sample culture are recommended for selecting cows for treatment.

A veterinarian should be consulted to evaluate cell counts and to recommend a treatment program. However, dairy producers must learn to accept that some forms of mastitis do not respond to treatment even with modern miracle drugs and that prevention and culling are the only ways to eliminate those mastitis cases. Producers should also be aware that although correct treatment of infected quarters will lower cell counts, the count may stay up or go down and then rise again. In those cases, the treatment may have been ineffective.

Cell counts can be useful to dairy producers who are purchasing lactating cows. Cows with composite milk cell counts in excess of 800,000 cells should not be purchased.

Despite it advantages, the SCC program does have some shortcomings, and considerable care must be taken in interpreting cell counts. Some factors other than mastitis can drastically affect the number of somatic cells in milk. For example, cell counts are high in milk from cows that are in their first week or last month of lactation, especially if their production is quite low in those periods. Periods of stress or infection other than mastitis can also cause increased cell counts. A stepped-on teat, udder injury, or systemic infection may cause a high count without udder infection.

Another problem with cell counts is that testing composite samples may hide an infected quarter because of the dilution effect. An infected quarter shedding 1,000,000 may not be detected when the three healthy quarters have counts of 350,000 or less. The DHI composite cell count does not indicate which quarter or quarters are infected. The affected quarters must be identified by the CMT or by having a veterinarian culture the milk from each quarter.

It is also important to remember that the SCC simply indicates which cows need attention; it does *not* tell which organism is causing the problem. For effective treatment, specific drugs must be matched with specific organisms.

It is possible for cows with a low cell count to suddenly flare up with severe mastitis without prior warning of high cell counts. These cases are usually caused by severe mastitis organisms such as the coliforms. Cows with low cell counts seem to be particularly susceptible to these infections, which usually result from unsanitary environmental conditions where udders are exposed to wet bedding, mud, and manure.

Meeting the 1983 Price Squeeze

STANLEY T. SMITH

Congress is presently considering changing the dairy price support program, and its decisions will no doubt affect every dairy producer's milk check. Although all of the details are not certain at this point, a price reduction of 3 to 5 percent seems quite likely. This kind of decrease in gross income, coupled with constantly increasing costs, will place some dairy farmers in a tight squeeze. Some will see profits diminish, some may see profits disappear, and some will be fighting for survival. To maintain a profitable business, dairy producers will have to double their efforts to improve management skills. Dairying will become a rough, highly competitive, low-margin business.

Two major factors influence net profit. Total income limits the amount of dollars with which the business has to work. From that point, production expenses determine the amount of net profit. Therefore, maximizing the net profit means increasing the gross income as much as possible while keeping production expenses in line. Some areas of expense can be trimmed or controlled more effectively than others. The first step in cost management is to determine which items you can control most effectively. The second step is to devise a plan to work in that direction.

Regardless of the situation, studies of milk production costs and profitability make one point clear: high individual cow production is the largest single factor determining profitability on a dairy farm. Efficient, high-producing cows are the main solution to a profit squeeze. Table 1 presents a summary of costs and returns for Illinois. This table shows that production *per cow*—not a greater number of cows—is one of the keys to higher

profits. Milking more cows may increase the gross income, but it does not necessarily increase net profit. Increasing production per cow has a direct effect on net profit because it reduces the cost per hundredweight of producing milk.

Table 1. 1982 Illinois Costs and Returns for Various Levels of Milk Production (Based on a 60-Cow Herd Size and Expressed on a Cow-Plus-Replacement-Heifer Basis)

	Milk production level (lb/cow/year)			
Item	10,000	12,000	14,000	16,000
Milk sales	$1,337	$1,604	$1,872	$2,126
Livestock sales	203	208	228	246
Feed costs	754	769	820	867
Variable costs	328	337	356	367
Capital costs	385	434	481	530
Ownership costs	156	156	156	156
Labor costs	288	288	324	360
Profit or loss	-371	-172	-37	+92
Milk price per cwt needed to break even	16.47	14.59	13.52	12.80

PRODUCTION RECORDS A MUST

Each dairy producer must analyze his business for strengths and weaknesses. If he wants his analysis to be accurate, he must keep individual cow production records. If he does not have this information, he will have to guess, and when margins are low, one cannot afford many mistakes. Most decisions affecting the dairy herd (such as feeding programs, culling, and breeding programs) depend upon having facts. The decisions can be no more accurate than the facts upon which they are based. Accurate health and breeding records should also be a part of the total record system.

Credit needs must be backed up by overall farm financial records. Individual lenders vary in their approach to loans. They usually want to see some indication of where the business is at the present time, some history of where it has been, and a well-planned idea of where it is going. Most lenders will require that you provide 1) a net worth statement, 2) a profit and loss statement, 3) a cash-flow projection, and 4) a budget, and some lenders may require additional information. The ability to supply these kinds of information can be critical in decisions regarding financing.

FEEDING STRATEGIES

Nutrition is the largest single operating expense associated with milk production. A poor feeding program may or may not lower production, but it can definitely raise production costs. Maximum efficiency and cost-return relationship will be achieved when the rations are balanced with the nutrient requirements of the cows. Overfeeding will result in higher feed costs, and underfeeding will prevent cows from producing up to their genetic potential.

The Illinois Dairy Herd Improvement Association (DHIA) data in Table 2 show the relationships between production and feed costs. As the production level increases, so does the daily feed cost: it takes more feed to produce more milk. The significant points are that the income-over-feed cost increases at a greater rate as production increases and the cost of feed per one hundred pounds of milk decreases. Since forage makes up about one-half of the typical dairy ration, it is necessary to have an accurate chemical analysis of forage quality to properly balance a ration. A forage analysis (usually $8 to $12 per sample) can be an excellent investment if it is properly used in the feeding program. Whether a dairy producer balances the ration himself or uses one of the many ration-balancing services available is a matter of choice. The important point is that the ration must be balanced. A savings of only 2¢ or 3¢ per cow per day results in a $400 to $500 yearly savings in a 50-cow herd. At the same time, a milk increase of as little as 1 pound per cow per day can produce $1,500 to $2,000 more income in a 50-cow herd. Either of these figures illustrates that it is definitely worth spending some time, money, or both to get the ration properly balanced.

Table 2. Feed Costs in 1,137 Illinois DHIA Herds, by Production Level

Production level (lb)	Number of herds	Feed cost per day	Income over feed cost per day	Feed cost per cwt
Under 9,000	6	$1.57	$0.73	$5.81
9,000 - 10,999	71	1.56	2.21	5.67
11,000 - 12,999	202	1.64	2.70	5.14
13,000 - 14,999	412	1.78	3.40	4.63
15,000 - 16,999	343	2.00	3.95	4.50
17,000 - 18,999	95	2.15	4.45	4.38
18,999+	8	2.31	5.30	4.09
ALL HERDS	1,137	1.85	3.43	4.83

The ration delivery system also needs to be considered. It is of questionable value to know what ration to feed if the system being used cannot deliver it accurately. Estimates of daily feedstuff intake must be as accurate as the nutrient analysis if cows are to be fed for maximum production at minimum cost. In many instances minor changes in the feed delivery system would result in better utilization of the ration. The cost of any major change should be weighed against the benefit expected.

Planning a feeding program in advance frequently saves money. An inventory of available feeds can be checked against the amount needed to feed the herd. If the inventory is in excess of needs, the surplus can be sold. When the needs exceed the inventory, purchases can be made at a more desirable time or ration adjustments can be made in advance. Whenever purchases are made at the last minute, the cost is usually higher.

Purchased supplements do not make up a large amount of the feed cost on the typical Illinois dairy farm. Nevertheless, shopping for the best buys, buying in bulk or large amounts when feasible, and contracting could all save a few cents per cow per day.

MASTITIS CONTROL

Mastitis is another area that works on both sides of the net profit picture. Treatment, additional labor, and cow losses through culling are direct costs that are felt by every dairy producer. Low-level or subclinical mastitis results in lowered production, but because it does not involve a cash outlay, it is frequently overlooked. Table 3 illustrates the amount of production lost through mastitis infection.

Table 3. Relationship between Average Somatic Cell Count, Percentage of Quarters Infected, and Lost Milk Production

Average somatic cell count	Quarters infected (%)	Lost milk production (%)	Lost milk yield per cow[a] (lb)
200,000	---	---	---
300,000	3.0	1.4	196
400,000	7.7	3.6	504
500,000	12.4	5.9	826
600,000	17.1	8.1	1,134
700,000	21.8	10.3	1,442
800,000	26.5	12.6	1,764
900,000	31.2	14.8	2,072
1,000,000	35.9	17.0	2,380

[a]Assumes 14,000-lb production.

The loss of production potential can easily exceed the cash costs of mastitis treatment. The somatic cell count program sponsored by the DHIA can help determine the size of the mastitis problem and monitor efforts to reduce the loss. Herd average cell counts in excess of 500,000 need immediate attention, and milking equipment and milking practices should also be checked.

To make a testing program work, be sure to consult your veterinarian and establish a treatment program. A variety of approaches will work, but all successful mastitis treatment programs 1) identify individual cows, 2) screen quarters to locate those that are infected, 3) isolate organisms, and 4) plan an effective treatment program. The decision on treatment depends upon the stage of lactation, the amount of milk produced per day, the organism(s) present, and the age of the cow. On the basis of these and other considerations, a cow may be treated during lactation, treated at time of drying off, or culled from the herd. These decisions can best be made with adequate records and consultation with the herd veterinarian.

The best time to treat most subclinical udder infections is at drying off. Several factors favor treatment at this time: the cure rate is higher than during lactation, the incidence of new infections is lower, damaged tissue may be repaired before freshening, clinical mastitis at freshening is reduced, and otherwise salable milk does not have to be discarded.

Teat dipping, overall sanitation, and sound milking routines are commonly accepted practices that will minimize both clinical and subclinical mastitis. Keeping the bedded and loafing areas as clean as possible will not only help reduce the spread of organisms, but will also shorten the milking operation time.

As a general rule, for each increase of 100,000 cells per milliliter, a decrease of about 1 pound of milk per cow per day occurs. Over a period of time, steps taken to reduce the somatic cell count in the bulk tank will increase the profitability of a dairy herd.

REPRODUCTIVE EFFICIENCY

Reducing the calving interval can improve net profit in several ways. It can eliminate long dry periods, it can minimize long, low-production lactations, and it ensures that more calves will be born per cow per year. In all these ways it allows a cow to be more productive each day of its life.

A good heat detection plan is the single most important factor in reducing the calving interval. Successful heat detection requires close observation at least three times a day (more frequently for some problem cows). Having records on individual cows makes this job easier. Time of observation is also important. Research studies have shown that nearly two-thirds of the cows will come into heat between 6 p.m. and 6 a.m. This means that a good detection program must include an early and a late observation period if it is to produce results.

A good record-keeping system is an essential step to good reproductive performance, and in some herds, improved breeding efficiency must begin with an improved identification program. Routine herd health records are an integral part of a good reproductive management program, since intelligent decisions cannot be made if the information needed is inaccurate or unavailable. Records should include the important dates in each cow's reproductive cycle. Calving, heat periods, breeding dates, and examinations are a few items that should be recorded. Recording the next anticipated heat period can also be helpful.

CAPITAL INVESTMENT

Large capital expenditures should be analyzed carefully. The amount of capital invested in dairy farming has increased steadily in recent years—partly because facilities cost more, but also because capital expenditures have been made to reduce the labor load. The high interest rates of the last few years have significantly increased the cost of operating when sizeable debt loads are involved.

If a dairy manager has contracted for a high debt load, he can do very little to alter that situation. Sometimes it is possible and advisable to work with a lender to restructure the debt load. Some shifting of the balance between short-term and long-term obligations might be possible and make the overall debt structure more manageable.

Increasing the debt load and consequently the amount of money needed to service that cost is risky when profits are low. This is not to say that a profitable dairy business should forego all capital expenditures. It is a sound practice to continually replace or

upgrade the capital investment in any business. If the business is sound and showing a profit, upgrading will not jeopardize future profits; it will simply mean that one will have to exercise more care and plan wisely when margins are low.

SUMMARY

The profit margin in dairy farming will certainly decline in the near future. Dairy farmers will need to use all of their management skills and all of the services available to them if their dairy operation is to remain profitable. More emphasis and importance will be placed on financial planning and adequate record systems.

Records are a must for a successful operation. All available data should be analyzed to identify strengths and weaknesses. Once weaknesses are identified, plans can be made to correct them. Each part of the dairy operation should be viewed with an eye toward improvement. Some consideration should then be given as to how each individual practice fits into an overall management plan.

It may not be possible to obtain maximum efficiency in each area of production. Some management decisions depend on others, and some are in conflict with others. The dairy producers that will succeed in the 1980s are those that will develop an overall strategy that makes the most of the strengths of their particular operation. Adapting a management plan to their own particular farm will be one of the keys to success.

University of Illinois
Research Reports

Using Sodium Bicarbonate and Limestone in High-Energy Rations

CARL L. DAVIS AND GENE C. McCOY

A total of 108 lactating dairy cows located at three universities (University of Illinois, University of Pennsylvania, and Pennsylvania State University) were fed high-energy rations (60 percent concentrate and 40 percent corn silage on a dry weight basis) from freshening to 16 weeks of lactation. The four experimental rations were 1) a control, 2) a control + 1.2 percent sodium bicarbonate, 3) a control + 1.4 percent limestone (fine particle size), and 4) a control + 1.2 percent sodium bicarbonate + 1.4 percent limestone. The concentrate was a typical grain mix of minerals, vitamins, 70 percent ground corn, and 26 percent soybean meal. The feeds were blended together and fed as total mixed rations to appetite.

Feed intake and production response to the treatments are shown in Table 1. Cows receiving the bicarbonate-supplemented diet (Diet 2) produced more milk of a higher fat test than cows fed the control or limestone-supplemented diets during the 16-week test period. Most of the increase in production from bicarbonate feeding occurred in the first 8 weeks of the test because the feed intake of cows on this treatment was higher during this period. Limestone supplementation had no effect on lactation performance. A combination of bicarbonate and limestone depressed feed intake and milk production. We conclude that sodium bicarbonate may be of significant value in the ration of the dairy cow in early lactation (from freshening to 8 to 10 weeks). The recommended level of supplementation is 0.75 to 1 percent of the ration dry matter, and supplementation should not exceed 1.2 percent of the ration dry matter.

Table 1. Production Response to Rations Supplemented with Sodium Bicarbonate and Limestone[a]

Diet	Milk yield (lb/day)	Butterfat (%)	Fat yield (lb/day)	4% FCM yield[b] (lb/day)	Protein (%)	Protein yield (lb/day)	Dry matter intake (lb/day)
Control	69.7	3.26	2.20	61.1	3.14	2.16	44.5
1.2% sodium bicarbonate	71.2	3.40	2.38	64.2	3.14	2.23	43.9
1.4% limestone	68.1	3.32	2.25	60.8	3.07	2.05	41.7
1.2% sodium bicarbonate + 1.4% limestone	65.3	3.52	2.25	59.7	3.06	1.96	41.2

[a]Average for period from freshening to 16 weeks of lactation.
[b]Four percent fat-corrected milk.

Formaldehyde Treatment of Soybean Meal

BRIAN A. CROOKER, JIMMY H. CLARK, AND ROGER D. SHANKS

Greater efficiency of protein utilization generally occurs when proteins escape microbial degradation in the rumen and are digested in the small intestine. This increased efficiency has resulted in attempts to increase the proportion of dietary protein that escapes ruminal degradation without decreasing microbial protein synthesis in the rumen. One technique employed has been formaldehyde treatment of dietary protein, which has increased wool growth and weight gains in sheep as well as weight gains in steers. The objective of this study was to ascertain whether feeding formaldehyde-treated protein to lactating dairy cows would improve performance. In the study, Holstein cows were fed during a complete lactation with untreated or formaldehyde-treated (0.3 percent) soybean meal in a diet that was either deficient in crude protein or at a recommended dietary crude protein content. Milk yield, milk composition, and body weight were then measured.

Throughout lactation, cows were fed individually ad libitum quantities of diets containing 50 percent roughage (1 part alfalfa-grass hay to 3 parts corn silage on a dry matter basis) and 50 percent concentrate (ground corn-soybean meal) on a dry matter basis. During the first 21 days of lactation, all cows were offered the same diet containing equal amounts of treated and untreated soybean meal. On day 22 of lactation, cows were assigned randomly to one of the four experimental diets, which they received for the remainder of the lactation period. The four experimental diets were derived from a factorial arrangement of dietary crude protein (12 and 14 percent) and formaldehyde treatment (untreated and treated soybean meal).

Increasing the crude protein content of the total ration dry matter from 12 to 14 percent did not significantly improve animal performance. Formaldehyde treatment of soybean meal had no significant effect upon body weight, milk yield, milk fat yield, or milk solids-not-fat yield (Table 1). Significant reductions occurred in both the milk crude protein percentage (from 3.11 to 2.94 percent) and the crude protein yield (from 2.27 to 2.13 pounds) during early lactation (days 22 to 119) when cows were fed formaldehyde-treated protein. This reduction was caused, in part, by a slight decrease in the digestibility of the crude protein in the treated soybean meal as compared to that in the untreated soybean meal (62 versus 66 percent). These results suggest that, to be effective in increasing the postruminal supply of protein, less than 0.3 gram of formaldehyde per 100 grams of soybean meal should be used when treating soybean meal for dairy cattle rations.

Table 1. Dry Matter and Crude Protein Intakes, Milk Production, and Body Weight of Cows Fed Diets Containing Untreated (SBM) or Formaldehyde-Treated Soybean Meal (FSBM) at Two Crude Protein Concentrations

	12% crude protein in total dietary dry matter		14% crude protein in total dietary dry matter	
Item	SBM	FSBM	SBM	FSBM
Dry matter intake (lb/301 days)				
Concentrate	6,791	6,802	7,117	7,082
Corn silage	4,477	4,499	4,741	4,743
Hay	1,531	1,509	1,551	1,445
Total	12,799	12,810	13,409	13,270
Crude protein intake (lb/301 days)	1,551	1,582	1,923	1,852
Production (lb/301 days)				
Milk	17,466	17,160	17,901	17,851
Milk fat	616	618	614	625
Milk protein	548	543	583	570
Milk solids-not-fat	1,434	1,408	1,481	1,489
Body weight (lb)				
Week 1	1,385	1,372	1,363	1,348
Week 43	1,493	1,491	1,492	1,516

Acetic Acid Treatment of Soybean Meal

JOHN L. VICINI, JIMMY H. CLARK, AND BRIAN A. CROOKER

Previous research at the University of Illinois has shown that infusing protein into the abomasum (fourth compartment of the stomach) of lactating cows increases milk and milk protein yields, presumably because more protein reaches the small intestine. This response has prompted a search for treatment methods that prevent protein degradation in the rumen without decreasing protein digestibility in the lower gut (abomasum and small intestine). Treating proteins with formaldehyde prevents ruminal degradation, but it often does not improve lactational performance of dairy cows, possibly because the formaldehyde overprotects the dietary protein and lowers subsequent digestion in the lower gut. Acetic acid treatment of protein also may prevent microbial protein degradation in the rumen. The objectives of this study were to compare the effectiveness of formaldehyde and acetic acid in preventing ruminal degradation of soybean meal and to determine whether the treatments would alter lower gut digestibility.

Soybean meals were either untreated, treated with 8 grams of acetic acid in 250 milliliters of hexane per 100 grams of soybean meal, or treated with a 0.3 percent formaldehyde solution. Ruminal degradation rates of crude protein and dry matter from the three soybean meals were determined during a 24-hour period by measuring the loss of nitrogen and dry matter from dacron bags suspended in the rumens of steers fed a diet containing 60 percent concentrate and 40 percent corn silage on a dry matter basis. Residues of soybean meals exposed to rumen fermentation for 12 hours were then incubated with proteolytic enzymes to determine the extent of digestion under conditions similar to those in the lower gut.

Crude protein and dry matter from both formaldehyde- and acetic-acid-treated soybean meal were degraded at a slower rate than crude protein and dry matter from untreated soybean meal (Table 1). The rate of degradation of crude protein and dry matter from acetic-acid-treated soybean meal was intermediate between the rates obtained for formaldehyde-treated and untreated soybean meals. The more slowly degraded dietary protein should supply more dietary protein and absorbable amino acids to the cow if digestibility in the lower gut is not depressed. After 3 hours of incubation of the soybean meals with proteolytic enzymes, no differences in the extent of digestion of the soybean meals were detected (Figure 1). However, after 6 hours of incubation, digestibility of the untreated, formaldehyde-treated, and acetic-acid-treated soybean meal increased 24, 10, and 31 percent, respectively, over the values obtained after 3 hours of incubation. The comparatively small increase in digestibility of the formaldehyde-treated soybean meal indicates that the formaldehyde-treated soybean meal was overprotected, resulting in a lower release of amino acids.

Table 1. Ruminal Degradation Rates of Dry Matter and Crude Protein from Untreated, Acetic-Acid-Treated, and Formaldehyde-Treated Soybean Meal

Treatment	Dry matter	Crude protein
	percent per hour	
None	6.5	8.2
Acetic acid	4.7	4.0
Formaldehyde	1.7	0.7

This study indicates that although soybean meal treated with acetic acid is more rapidly degraded in the rumen than protein treated with formaldehyde, the amino acids from soybean meal treated with acetic acid may be more available for absorption in the lower gut. Acetic acid can also serve as an energy source for the cow. Thus, protecting proteins with acetic acid may be a useful means of increasing the availability of dietary amino acids to the lactating cow. Additional studies will be required before it will become practical to use in feeding dairy cattle.

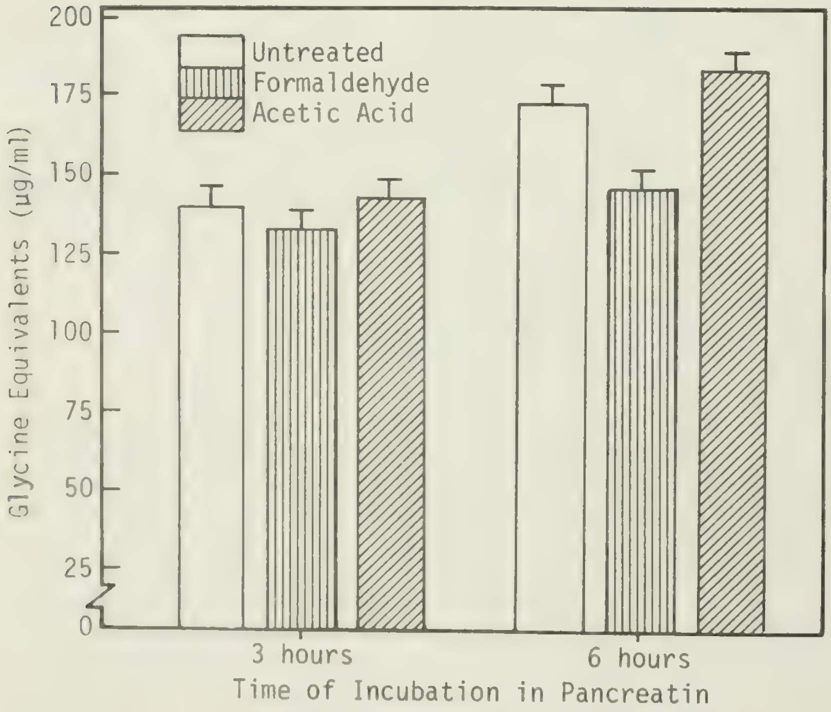


Figure 1.

Alpha-amino nitrogen (glycine equivalents) concentration after 3 and 6 hours of in vitro *incubation with pancreatin, of untreated, formaldehyde-treated, or acetic-acid-treated soybean meal that had been exposed to rumen fermentation for 12 hours.*

Feeding Value of Wet Corn Gluten Feed

CARL L. DAVIS, CHARLES STAPLES,
GENE C. McCOY, AND JIMMY H. CLARK

About three and one-half million tons of by-products from corn wet-milling industries are used as livestock feeds each year. In the past, most of these by-products have been marketed in a dry form. However, higher energy costs have stimulated interest in finding ways to maximize their use as wet feeds for ruminants. Since most of the wet-milling industries are located in Illinois, Iowa, and Indiana, livestock producers in those states could have ready access to an abundant feed source if nutritive value and economics were favorable.

This study was conducted to establish the maximum amount of wet corn gluten feed (WCGF) that could be used in the rations of lactating dairy cows without depressing milk production. The relative nutritive value of the by-product in relation to corn and soybean meal was also estimated.

Four diets were formulated. In all diets corn silage was the sole roughage, making up to 50 percent of the total ration dry matter. Wet corn gluten feed (43 to 45 percent dry matter) was incorporated into the ration at levels of 0, 20, 30, and 40 percent of the ration dry matter. Ground corn, soybean meal, and mineral supplements were blended together in varying amounts to equalize all diets with respect to crude protein (15.8 percent), calcium (0.6 percent), and phosphorous (0.45 percent). All feeds (corn silage, WCGF, and grain mix) were blended together into complete feeds and fed twice daily to 20 lactating dairy cows to appetite. The experiment lasted 16 weeks and was designed so that each cow would receive each diet for a 4-week period.

Data for feed intake, milk yield, and milk composition are given in Table 1. The dry matter intake of cows fed the 30 and 40 percent WCGF diets was significantly lower. The lower intake resulted in lower daily milk yield. However, cows on the 30 to 40 percent WCGF diets also had the highest fat tests; as a result, cows on all four diets produced essentially equal yields of 4 percent fat-corrected milk (FCM). The higher fat tests resulted from a higher fiber intake, which produced a rumen fermentation with a higher proportion of acetate and a lower proportion of propionate.

Table 1. Dry Matter Intake, Milk Yield, and Milk Composition of Cows Fed Rations Containing Wet Corn Gluten Feed

Measure	Percentage of wet corn gluten feed in ration			
	0	20	30	40
Dry matter intake (lb/day)	52.7	51.3	48.9	47.3
Milk yield (lb/day)	67.1	65.7	61.7	61.9
Milk fat (%)	2.9	3.0	3.2	3.2
Milk protein (%)	3.2	3.1	3.1	3.1
4% FCM (lb/day)[a]	55.8	55.5	53.9	54.6

[a]Four percent fat-corrected milk.

The actual amounts of WCGF consumed by the cows on the 40 percent ration ranged from 35 to 57 pounds per cow per day. All diets were readily accepted by the cows. The dry matter percentages of the four rations were 64.2, 52.7, 49.7, and 46.9 for the 0, 20, 30, and 40 percent rations, respectively. As has been noted with other high-moisture feeds, dry matter intake is reduced when the total ration contains more than 50 percent moisture.

The efficiency of using feed dry matter for milk production (pounds of 4 percent FCM per pound of dry matter consumed) was essentially the same for all rations. Since WCGF was substituted for corn and soybean meal in the rations, it would appear that the nutrients in the WCGF were utilized equally as well for milk production as those in corn and soybean meal.

From the results of this study, it is concluded that wet corn gluten feed can be incorporated into the rations of lactating dairy cows at levels up to 25 to 30 percent of the total dry matter with good results. Its economic value should be based on the relative value of corn and soybean meal that it replaces.

Water Consumption in Early Lactation

MICHAEL R. MURPHY, CARL L. DAVIS, AND GENE C. McCOY

Nineteen University of Illinois cows were used in a study to examine relationships between water consumption and dry matter intake, milk production, sodium intake, and environmental temperature. Data from cows fed four different diets (corn silage and wet corn gluten feed combinations) were pooled for analysis. The experiment was conducted from February 2 to July 22, 1981. A summary of our observations during the first 16 weeks of lactation is presented in Table 1.

Water consumption was affected by dry matter intake, milk production, sodium intake, and environmental temperature. The daily amount of water required (pounds per day) was estimated by adding together 1.58 x dry matter intake (pounds per day), 0.9 x milk production (pounds per day), 0.11 x sodium intake (grams per day), 0.46 x mean minimum temperature (°F), and 35.2 pounds of water. An additional 25.6 pounds per day was contributed by water in the feed. It is apparent that large amounts of water are normally consumed by lactating dairy cattle. Our results emphasize the fact that water, the least expensive nutrient, should be readily available either from automatic waterers or in amounts sufficient to meet the cow's requirements as outlined above.

Table 1. Variables Measured during Early Lactation

Variable	Mean	Minimum	Maximum
Water intake (lb/day)	196.8	38.4	338.7
Dry matter intake (lb/day)	41.8	11.5	60.0
Milk production (lb/day	73.0	7.7	112.4
Sodium intake (g/day)	73.6[a]	12.0	153.0
Mean minimum temperature (°F)	46.5[b]	9.0	68.7
Mean maximum temperature (°F)	66.5[b]	28.0	89.1
Overall mean temperature (°F)	56.5[b]	18.7	78.8

[a]Equal to 2.6 ounces of sodium: the amount contained in 6.6 ounces of salt or 9.5 ounces of sodium bicarbonate.
[b]Weekly mean temperature.

Milk Fat: A Review of Its Synthesis and Secretion

CARL L. DAVIS, RIC GRUMMER, AND HOLLY WHETSTONE

Fat is the most variable component of milk. Its concentration is influenced by breed, differences in genetic makeup within a breed, diet, stage of lactation, season of year, ambient temperature, and body condition. To regulate the fat content of milk, it is important to understand the basic mechanisms of milk fat synthesis and secretion. This article will first deal with how milk fat is made and will then discuss how diet affects milk fat content.

COMPOSITION OF MILK FAT

Milk fat is 98 percent triglyceride, which is a combination of glycerol (polyalcohol) and fatty acids (see Figure 1). Ruminant milk fat is unique in that it contains a high proportion of short-chain fatty acids (4, 6, 8, and 10 carbon chain lengths). These fatty acids are not found in the milk fat of nonruminant species (except in the rabbit), are not present in the body fat of any species, and are not present in any feeds (except in silages).

Researchers previously thought that the short-chain fatty acids were breakdown products of long-chain fatty acids derived from the diet or mobilized from fat stores in the body. Now we know that they are synthesized within the mammary gland from precursors (acetate and B-hydroxybutyrate [BHBA]) removed from the blood (Figure 2). The fatty acid synthesizing system in the mammary gland produces even-carbon-numbered fatty acids of 4 to 16 carbon lengths. These short-chain fatty acids represent about 50 percent by weight of the total fatty acids in milk fat. The other half of the fatty acids—those of 16 and 18 carbon lengths—come preformed from the blood. These long-chain fatty acids consist of both saturated (stearic) and unsaturated (oleic and linoleic) acids.

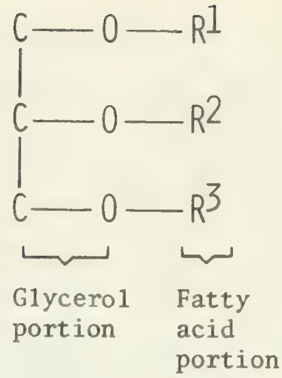


Figure 1. Basic triglyceride structure.

SYNTHESIS OF MILK FAT

Short-chain fatty acids (Figure 3). As pointed out above, the precursors of the short-chain fatty acids are acetate (a 2-carbon acid) and BHBA (a 4-carbon acid). Both originate in the paunch, or rumen. Large quantities of acetate are produced in the rumen through the breakdown of carbohydrates (sugars, starches, and cellulose) by microorganisms. These same organisms produce butyric acid, which is absorbed into the blood and converted to BHBA. Acetate and BHBA are selectively extracted from blood by the mammary gland. Once in the mammary cell, they are activated to a coenzyme A (CoA) derivative so that they can undergo other biochemical reactions. For example, a high proportion of the activated acetate is converted to a more reactive compound called malonyl-CoA. This conversion (acetyl-CoA to malonyl-CoA) is the most limiting step in the whole scheme of fatty acid synthesis. Thus, if we wished to explore the genetic basis for why one cow produces more milk fat than another cow, this biochemical step would be a likely place to probe. BHBA does not lead to the formation of either acetyl-CoA or malonyl-CoA, but instead is activated to B-hydroxybutyryl-CoA and serves as a "primer" in getting the synthetic process started. Once the primer is formed, malonyl-CoA supplies two carbons in successive steps to make a fatty acid that has an even number of carbon units and is two carbons longer. Although we can manipulate this fatty acid synthesizing system to make a particular pattern of fatty acids under test-tube conditions, we are not sure how this synthesis occurs in the mammary gland.

Long-chain fatty acids. As pointed out earlier, long-chain fatty acids are preformed and are removed from the blood. Since they are not water soluble, they are transported in the blood along with other substances such as proteins, phospholipids, glycerol, and cholesterol. All these substances are packaged into discrete water-miscible particles termed lipoproteins. The specific lipoprotein that transports the fatty acids to the mammary gland is very-low-density lipoprotein (VLDL) and is rich in "fat." As the VLDL particles pass through the blood vessels of the mammary gland, they are broken down by an enzyme (lipoprotein lipase) that is located in the walls of the capillaries. The breakdown releases the long-chain fatty acids, which then pass into the mammary cell along with the associated glycerol. Once in the mammary cell, the long-chain fatty acids become activated to CoA derivatives and the glycerol becomes activated to glycerol-phosphate.

Triglyceride formation. The short- and long-chain fatty acids are attached to the glycerol molecule in an orderly and systematic fashion. There are three points of attachment to the glycerol molecule (Figure 1). Some fatty acids are positioned at random onto glycerol, while others occupy a specific position. For example, lauric acid (a 12-carbon fatty acid) is randomly assigned, while butyric acid (a 4-carbon fatty acid) is positioned primarily on the third carbon of the glycerol structure.

Once the triglycerides are made, they tend to clump together and form fat droplets, which move through the secretory cell toward the side adjacent to the lumen (the space surrounded by secretory cells). They are engulfed by a portion of the cell membrane, pinched off into the lumen, and mixed with other components such as lactose, protein, minerals, and water to become milk.

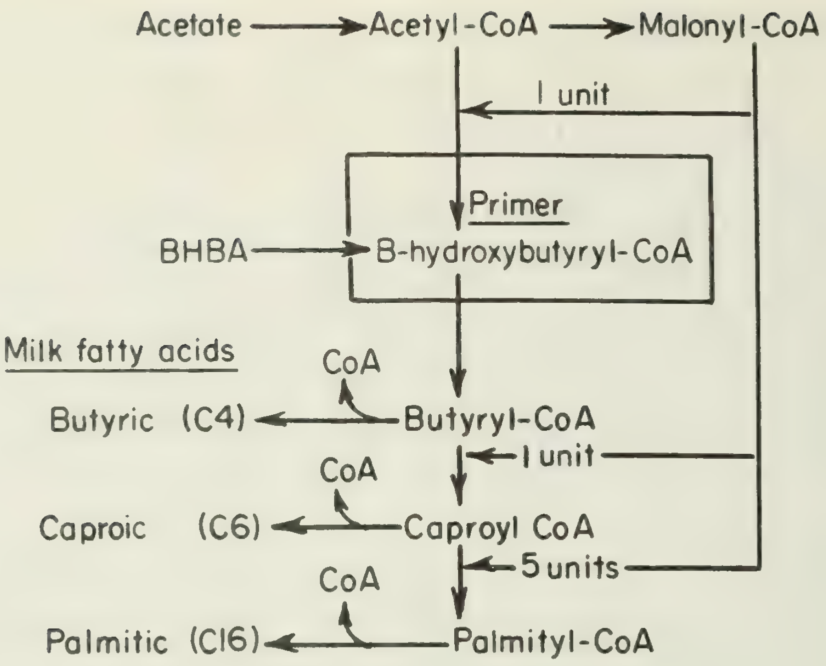


Figure 2. Overview of milk fat synthesis in the mammary gland of the cow.

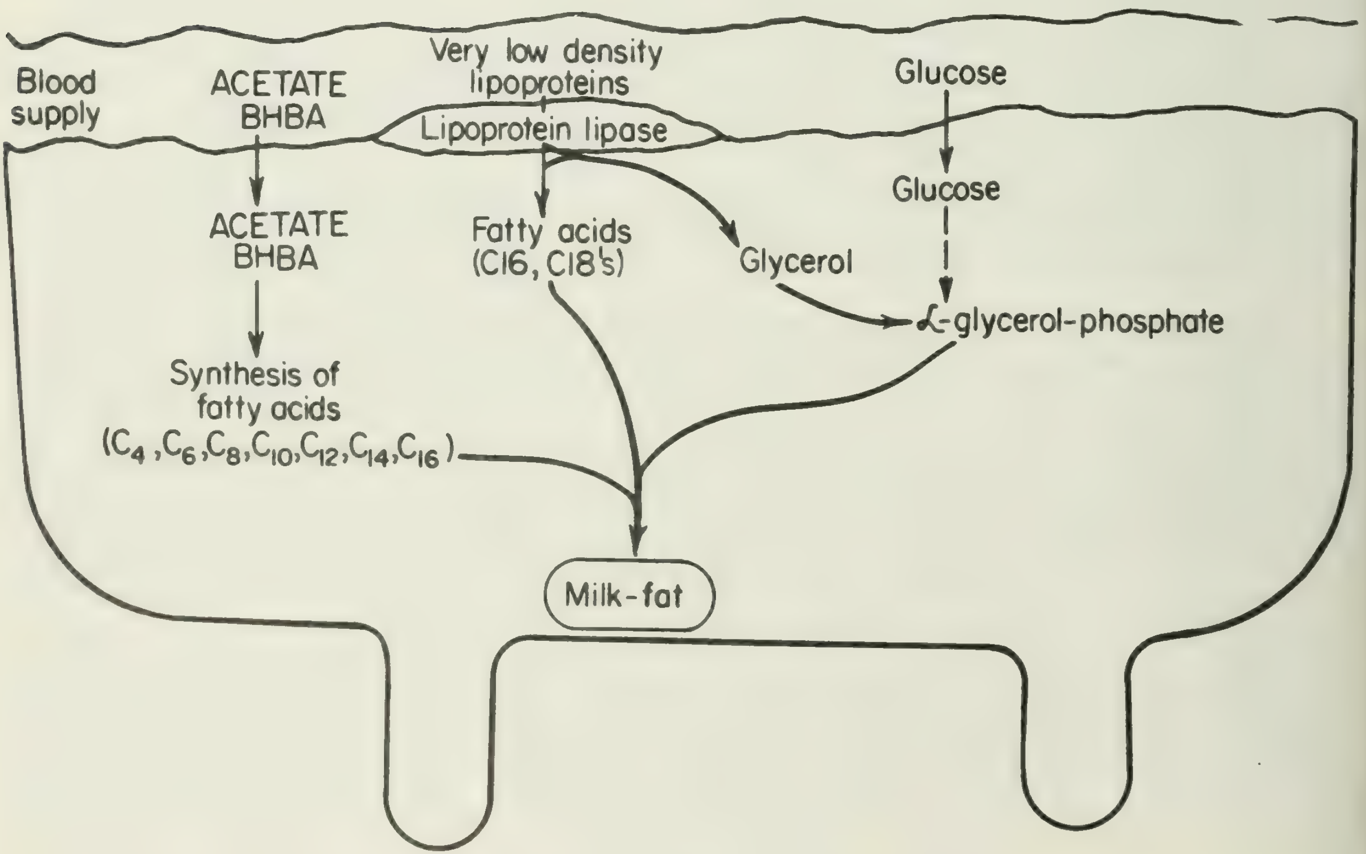


Figure 3. Mechanism of fatty acid synthesis in the mammary gland of the cow.

MILK FAT AND DIET

As mentioned in the beginning, milk fat content is influenced by many factors, and one of the most important is diet. Practices that have been shown to lower the fat content are 1) feeding high levels of grain with restricted amounts of forage, 2) feeding liberal amounts of grain with finely chopped forages, 3) supplementing normal diets with oils that are high in long-chain unsaturated fatty acids, and 4) grazing certain pasture plants, such as young oats and pearl millet. Except for the oil-supplemented diets, all these diets tend to suppress the amount of saliva produced, and this suppression leads to an acid (low pH) rumen. These conditions result in an alteration of rumen fermentation and a higher than normal production of propionic acid. When propionic acid reaches 25 percent or more (molar basis) of the fermentation acids in the rumen, the percentage of milk fat decreases. Milk from Holstein cows, which normally tests about 3.5 percent fat, may drop to as low as 1.0 percent if the rumen propionic acid makes up 40 percent of the total acids. Many theories have been proposed to explain this effect, but none seem to be satisfactory. To prevent or correct a low-fat milk problem, the dairy producer should make sure that his cows have an adequate intake of coarse forage. It is generally recommended that the total ration consumed by the cow contain 15 to 17 percent crude fiber. However, it is important that this fiber is in a coarse form, not chopped finely, ground, or pelleted. If these conditions cannot be met, then a buffer must be incorporated into the ration. The most widely tested buffer is sodium bicarbonate, and the recommended level for its use is 0.75 percent of the total ration dry matter. Lower levels may be ineffective, and levels above 1 percent can lead to feed refusals.

Dairy farmers in the past have not supplemented diets with oils. However, there now appears to be a trend toward greater use of unprocessed high-oil seeds such as soybeans, cottonseeds, or sunflower seeds in cattle rations as a means of increasing energy content. It is likely that a depression in fat test will occur if high amounts of the ground, high-oil seeds are incorporated into the rations of lactating cows.

Yes, Select for Milk Protein

ROGER D. SHANKS AND MICHAEL GROSSMAN

Although dairy producers currently are not paid on the basis of pounds of milk protein, there may be pricing of milk for protein content in the future. Selecting for protein content would result in a higher-quality product, which, coupled with an active advertising campaign, could stimulate per capita consumption. Increased consumption would in turn reduce the milk surplus. In addition, selecting for milk protein would decrease gains in milk yield and therefore lower energy costs.

Selection for increased milk protein should result in a lower milk yield per cow than what would be expected from selection on milk yield alone. In the Guernsey and Brown Swiss breeds, the milk yield should be about 93 percent of what would be expected from selection on milk yield alone, and in Jerseys, it should be about 82 percent; in Holsteins, however, it should be only about 70 percent. How far are we from these changes? By January of 1982, 98 active artificial insemination (AI) U.S. Holstein bulls had been evaluated for protein. By July this number had increased to 185. Ayrshires had the highest percentage (69 percent) of active AI bulls evaluated for protein (9 out of 13). The number of active AI bulls by breed for which Predicted Difference (PD) for protein was calculated was as follows: Jersey—37; Guernsey—19; Brown Swiss—16; Red and White—2; Milking Shorthorns—0. Only 28 percent of the active AI bulls (268 out of 955) had sufficient numbers of daughters tested for protein to allow testing for PD. It is apparent that more bulls must be evaluated for protein so that the information needed for selection will be available when the price increases correspond to the quality of milk produced.

Milk yield reductions would lower energy costs for the dairy farmer. The cost of energy to cool milk is dependent on the volume of milk. The time spent running compressors and vacuum pumps is also directly related to the volume of milk. Obviously, transportation cost is associated with milk volume. Milk processing procedures are more efficient when there is a larger than minimum percentage of milk protein and solids.

In most breeds, selection for increased milk protein yield is expected to produce a small increase in the percentage of protein in milk. Testing cows for percentage milk protein is the first step toward selection for increased protein yield. These efforts, together with an advertising campaign for milk protein content, would be expected to generate more revenue for the dairy industry.

Breeding Philosophies of Illinois Dairy Producers

ROGER D. SHANKS, KATHLEEN A. ROONEY, AND MICHAEL F. HUTJENS

"I don't think anyone will come up with a sure way to breed the top cow."

"You can try very hard and still get poor heifers."

"The perfect cow has not been bred, but we are trying."

These are a few samples of the 171 comments made by the 591 Illinois dairy producers who returned a questionnaire on breeding practices. We found that dairy producers are realistic, but also enthusiastic, about trying to breed the perfect cow. First, a thank you to the Illinois dairy producers who participated in this study—Table 1 indicates the percentage of questionnaires that were returned. We were satisfied with the 51 percent return we received from the entire state. The region with the best return rate was the "rest of the state" at 58 percent (for descriptions of the regions, see the footnotes to Table 1). Sixty-four percent of the dairy producers with the highest-producing herds returned the questionnaires.

Table 1. Percentage of Questionnaires Sent Out that were Returned, by Region and Milk Production Group

Region	Milk production (lb/cow/year) <13,000	13,000-14,300	14,300-15,700	>15,700	Entire state
Northwest[a]	31	51	53	64	48
Chicago[b]	40	49	53	62	52
St. Louis[c]	24	52	53	64	53
Rest of state	41	68	58	66	58
Entire state	34	53	54	64	51

[a]The 7 counties in northwest Illinois that border Wisconsin and Iowa.
[b]The 15 counties immediately east and slightly south of the northwest region, and surrounding the Chicago metropolitan area.
[c]The 16 counties east of St. Louis.

Table 2 shows regional differences in 305-day, mature-equivalent, rolling-herd averages for milk and fat production, fat percentage, and other herd traits. The St. Louis region had the highest milk production and the lowest fat percentage. The Chicago region produced the most total fat and had the highest fat percentage. Days in milk were similar in all regions but were slightly lower (85.5 percent) in the northwest region. The St. Louis region had the largest herd size. All the herd participating in this study were defined as Holstein herds by the Dairy Herd Improvement (DHI) system. In the northwest region, 17 percent of the herds were registered, and in the St. Louis region, 47 percent of the herds were registered. The percentage of Grade A milk was high in all regions, ranging from 87 percent in the northwest region to 100 percent in the St. Louis region.

Information on several breeding statistics, including the number of artificial insemination (AI) organizations per herd, the number of bulls per 100 cows, consideration of calving ease for mating heifers, consideration of calving ease for mating cows, and the use of young sires, were reported in the *1982 Dairy Days Report*. The extent of AI use, the bull selectors used, and the criteria used in selecting bulls are reported here (Tables 3 and 4).

Table 2. Regional Herd Differences[a]

Trait	Northwest	Chicago	St. Louis	Rest of state
Number of herds	241	131	108	111
Milk (lb/cow/year)	14,440	14,969	15,432	14,969
Fat (%)	3.79	3.83	3.68	3.70
Fat (lb)	546	572	566	552
Days in milk	85.5	86.5	86.2	86.4
Herd size	55.5	53.9	65.5	53.2
% registered	17	46	47	27
% grade A	87	97	100	98

[a]See footnotes for Table 1 for region descriptions.

Table 3. Differences in Use of AI and Bull Selector, by Region[a]

Trait	Northwest	Chicago	St. Louis	Rest of state	Entire state
Use of AI (%)	96	95	98	95	96
Bull selector (%)					
Self	70	84	79	83	78
AI technician	24	18	14	17	19
AI organization	25	12	21	12	19
Consultant	10	7	13	13	10

[a]See footnotes for Table 1 for region descriptions.

Table 4. Differences in Use of AI and Bull Selector, by Milk Production

	Milk production (lb/cow/year)			
Trait	<13,000	13,000-14,300	14,300-15,700	>15,700
Use of AI (%)	92	94	98	99
Bull selector (%)				
Self	73	68	84	86
AI technician	23	25	17	13
AI organization	16	16	19	18
Consultant	9	11	10	12

Only 96 percent of the producers who participated in the questionnaire used AI (Table 3). Since daughters of the average AI bull produce 1,000 pounds more milk and 30 pounds more fat than daughters of the average non-AI bull, there is no excuse to not use AI. The percentage of those who use AI is significantly higher in the high-producing herds than in the low-producing herds (Table 4).

Tables 3 and 4 also indicate the bull selectors used. Dairy producers select most of their bulls themselves: the lowest percentage of producers that selected their own bulls was 70 percent in the northwest region, and the highest percentage was 84 percent in the Chicago region (Table 3). AI organizations were recognized as the second most popular bull selectors in the northwest and St. Louis regions. The percentages in Table 3 for bull selectors used add up to more than 100 because more than one classification of bull selector was identified by many producers. Dairy producers were most popular as selectors in all milk production groups (Table 4). AI technicians were more popular as bull selectors in below-average herds than in above-average herds, and the percentage of producers who chose their own bulls was greatest in the high-producing herds.

Regional differences in breeding philosophies regarding sire selection were small (Table 5). Udder conformation of daughters of a sire and predicted difference (PD) milk ranked first or second in all regions. Feet and legs were considered the third most

important trait in all regions. The fourth-ranking trait was either PD type or PD percent fat. Stature was intermediate among the 11 traits ranked. The regions differed on how they ranked PD fat: it tied for 5th in the northwest region and was as low as 8th in the St. Louis region. PD dollars and total performance index (TPI), which are multitrait indexes, were next in rank. Emphasis on semen price followed in 10th, and popularity was the lowest-ranking trait in all regions. One producer commented, "If they [the bulls] have what we loo for, they will be popular." This may also be the case for PD dollars and TPI; however, dairy producers must be aware of the opportunity to screen bulls on these multitrait indexes. Once the best group of bulls is selected from rankings based on multitrait indexes, the producer can then evaluate the individual traits to determine the most appropriate mating for those bulls.

Regional differences in ranking traits for female selection are given in Table 6. All respondents indicated that milk production, udder conformation, and feet and legs ranked 1st, 2nd, and 3rd. and that stature and final score ranked 8th and 9th. There were small fluctuations among the intermediate traits of fat percentage, mastitis history, longevity, and reproductive history. Interestingly, the northwest and Chicago regions rankec fat percentage 4th, while the St. Louis region ranked it 7th. This response corresponds to the actual fat percentages in the herds. In addition, the St. Louis region, which had largeı herds, ranked longevity and reproductive history higher than fat percentage.

Table 5. Ranking of Traits for Sire Selection, by Region[a]

Trait	Northwest	Chicago	St. Louis	Rest of state	Entire state
Udder conformation of daughters	2	1	1	2	1
PD[b] milk	1	2	2	1	2
Feet and legs	3	3	3	3	3
PD type	5[c]	4	4	5	4
PD percent fat	4	5	6	4	5
Stature	7	6	5	6	6
PD fat	5	7	8	7	7
PD dollars	8	8	7	9	8
TPI[d]	10	9	9	8	9
Semen price	9	10	10	10	10
Popularity	11	11	11	11	11

[a]See footnotes for Table 1 for region descriptions.
[b]Predicted difference.
[c]Tied with PD fat.
[d]Total performance index.

Table 6. Ranking of Traits for Female Selection, by Region[a]

Trait	Northwest	Chicago	St. Louis	Rest of state	Entire state
Milk production	1	1	1	1	1
Udder conformation	2	2	2	2	2
Feet and legs	3	3	3	3	3
Fat percentage	4	4	7	5	4
Mastitis history	5	6	6	4	5
Longevity	7	5	4	7	6
Reproductive history	6	7	5	6	7
Stature	8	8	8	8	8
Final score	9	9	9	9	9

[a]See footnotes for Table 1 for region descriptions.

What do these tables and figures mean?

1. The fact that the dairy producers in the highest-producing herds found the time to complete the questionnaire appears to suggest that a successful producer recognizes the value of information.

2. Regions in Illinois differ in much the same way in that each herd is unique and different from its neighbor.

3. Artificial insemination (AI) is a tremendous technological tool that is not used to its fullest. The figures show that high production *does* correlate with the use of AI.

4. Dairy producers make most of the decisions in selecting bulls. Information on PD milk and other secondary traits is essential for making wise decisions.

5. Dairy producers place limited emphasis on multitrait selection indexes for sire selection. Udder conformation of daughters, PD milk, and feet and legs were considered the most important traits.

6. Milk production should be the most important female selection trait.

A word of caution: increasing energy costs may shift selection emphasis away from milk production and toward selection for milk solids, protein, and fat.

Selection for Milk and Meat

SUWAT RATTANARONCHART AND MICHAEL GROSSMAN

Although dairy cows yield relatively low-quality carcasses, they have become an important source of lean meat in the United States. Some attention and interest has been given to comparing dairy steer growth and carcass traits to growth and carcass traits of beef steers. The suitability of using dairy breeds for beef has been studied in the larger breeds. It was found that, in general, dairy breeds have a highly satisfactory growth rate (average daily gain) and feed efficiency (feed per pound of gain). Carcass grades have been lower for dairy breeds than for beef breeds, and dressing percentages have usually been 2 to 3 percent less than for beef breeds.

The relationship between milk production, growth rate, and carcass quality has also been studied. In the United States, the literature is inconsistent regarding correlations between lactation production and growth rate in dairy cattle. Positive phenotypic correlations varying from 0.1 to 0.4 between several measures of lactation milk yield (for example, total milk yield or milk yield per 1,000 pounds of cow) and several measures of growth rate (for example, change in heart girth and body weight) have been reported. However, genetic studies on lactation production and growth rate in Great Britain, Germany, the Scandinavian countries, and Israel have shown small genetic correlations between lactation milk yield and growth rate. If these results are correct, increased milk production will not be expected to produce a significant correlated response in average daily gain.

There are few reports on genetic correlations between lactation production and carcass traits. Most have found these correlations to be small or zero. However, we have found moderately negative, and in some instances, large and positive correlations between lactation traits and several carcass traits. For example, the estimated genetic correlation between milk production and loineye area or overall carcass grade was +0.85, whereas that between milk production and maturity score was -0.47. Sampling errors of estimates of genetic parameters were large. These findings indicate that progress in selection for lactation production may give correlated responses for carcass traits in either the negative or positive direction. Therefore, care should be taken when selecting for both lactation and carcass traits in dairy cattle.

Prospects for Genetic Engineering

WALTER HURLEY

Genetic engineering, biotechnology, recombinant DNA—these words are presently generating considerable excitement. To the biologist, they mean exciting new tools and new approaches to the study of living systems. To the veterinarian, they mean the production of new drugs in large, inexpensive quantities and the potential for cures to genetic diseases. To

the agricultural producer, they may mean healthier animals and crops that grow faster and more efficiently. Although the full potential of genetic engineering will not be realized for years to come, we are slowly working toward many of these goals.

Engineering is a science by which properties of matter and sources of energy in nature are made useful to man in structures, machines, and products. Genetic engineering uses information contained in genes to make life forms behave in a specified way. We do not have the ability to create life, as the popular press sometimes implies. We are dealing with a technology; that is, we have the techniques by which we can genetically *alter* existing life forms. Our innovative techniques are very similar to those used in nature as part of the evolutionary process: Mother Nature created them first, and we are only able to borrow her ideas. There really is nothing new under the sun.

Potentially, bacteria can be engineered to do a multitude of things. The foot and mouth disease vaccine and the bovine growth hormone are two proteins being synthesized by genetically engineered bacteria that may be available for marketing within the next few years. Theoretically, any protein—hormones, hormone receptors, structural proteins, and enzymes—could be made this way, and these bacteria-produced proteins would be easier to obtain in large quantities than if they were manufactured by our present expensive tissue-extraction procedures. Bacteria could also be altered to produce compounds they would not normally produce—for example, vitamins and steroid hormones. Likewise, bacteria could produce enzymes that would permit them to rapidly degrade industrial pollutants or more rapidly decompose animal waste. The gastrointestinal bacteria that play a large role in animal nutrition could also be engineered to increase feed efficiency.

All is not blue sky and roses, however. Most existing microbial populations are mixtures of many types of bacteria, protozoa, yeast, and algae. For instance, in the rumen we could take out one kind of bacteria and genetically engineer it to digest fiber. If we now place it back in the rumen, it might disappear because it cannot properly compete with existing rumen organisms. Obviously, successful genetic engineering of microorganisms must await more knowledge about the microorganisms' normal environment and interactions—whether in the cow's rumen, in a pig's intestine, or in the manure tank. All organisms must be investigated because each bacterium and protozoan is a different entity.

It is also feasible to genetically engineer animals and plants. In the dairy industry, we have the potential to make cows grow faster and give more milk—both on less feed. We may be able to cure genetic diseases. Nevertheless, we still face many problems. Plant and animal genes and cells are much more complex than bacterial cells. The plants and animals of most interest to us in agriculture are multicellular organisms, which introduce such problems as getting the recombinant DNA (which contains the gene) to be incorporated into the cell's own chromosomes so that all cells derived from it will carry the gene.

Lactation is on every dairy producer's mind. But how many genes control lactation? Which one or ones are most important? What other genes are important in regulating those genes responsible for lactation? Which set of those genes is essential for engineering higher-producing cows? For instance, we could isolate the cow prolactin gene and put it into an embryo in the hope of getting higher-producing cows. But that embryo already has at least one good prolactin gene. Will the genetically engineered animal with two genes have twice as much prolactin in its blood, or will the normal regulation of the prolactin gene keep the hormone level within the normal range found in the nonengineered cow? If it does, then we will have done a great deal of work for nothing, because the cow will not give any more milk. Should we instead be looking at those genes that regulate prolactin synthesis and secretion? Or would it be better to take the prolactin gene from another species and put it in the cow where it might be regulated differently than the original cow gene and so stimulate the cow to give more milk? These are the kinds of problems and questions that must be answered before the potential of genetic engineering can be fully realized. The answers to these questions require a great deal more knowledge of the basic biology of lactation than we currently have.

The means by which genes can be obtained from one organism and placed in another is referred to as Recombinant DNA Technology. When selecting for high-producing cows, we are selecting for a set of genes involved in milk production, but we cannot really identify the specific genes that are involved. Recombinant DNA technology allows us to specifically

examine one gene at a time. We are in fact working directly with the genetic material—the DNA. With this technology we are also developing specific probes for doing research on the tissues that express a particular gene.

Several projects using recombinant DNA technology to study dairy cattle are being undertaken in the University of Illinois Department of Dairy Science. One project is attempting to identify the bovine placental lactogen gene. Placental lactogen is synthesized and secreted by the placenta and increases milk synthesis by the mammary gland. Statistical evaluations of factors influencing milk production indicate that the sire of a fetus may have an effect on the subsequent lactation of the dam that is carrying that fetus. The physiological basis for this effect very likely involves placental lactogen. The pregnant cow is under the influence of placental lactogen for most of gestation. We do not know how this hormone affects the developing or lactating mammary gland, the other tissues involved in lactation, or the fetus. Nor do we know how placental lactogen secretion from the placenta is regulated. Before we can fully understand the physiological significance of this hormone in the bovine, we must understand its molecular biology. Placental lactogen has been well characterized and studied in the human, and to a lesser extent in other species, but very little is known about it in the bovine—partly because we have not had a purified hormone. However, bovine placental lactogen *has* recently been purified and was found to be 50 percent larger than expected. The basic explanation for its unexpectedly large size lies in its gene. We are in the process of identifying and characterizing the bovine placental lactogen gene, and our findings will tell us why the bovine hormone is larger than expected and what evolutionary events took place to cause that change. This research may suggest why the dairy cow is such a great milk producer. Moreover, we will be able to use the DNA probes developed during this study to more closely study the regulation of the placental lactogen gene. Isolated bovine placental lactogen gene DNA may be used in early genetic engineering experiments in collaboration with the University of Wisconsin.

Another project is being undertaken using recombinant DNA techniques to establish the genetic basis for an enzyme deficiency in cattle. Orotic acid is a natural compound in cow's milk. Unusually high levels of milk orotic acid are caused by an enzyme deficiency that is apparently the result of a mutation in the enzyme's gene. We will isolate and characterize the gene for this enzyme and determine the nature of the mutation responsible for the enzyme deficiency. Information gained from this study will be used to develop a molecular test to rapidly screen cattle for the abnormal gene. This test will act as a prototype for other tests to screen cattle for deleterious genes. For example, this type of test could be used to detect a mutant gene before it is rapidly spread by artificial insemination.

Another project aims to understand further the transport of antibodies from blood into the colostrum. The newborn calf needs the mother's antibodies for survival because its own immunologic defense systems have not yet become operative. In cattle, the antibodies (immunoglobulins) are transferred from the blood to the colostrum across the mammary epithelium and are subsequently absorbed in the calf intestine. Despite the critical importance of immunoglobulin transport for calf health and survival, very little is known about the mechanism of the transport system. We do know, however, that blood immunoglobulins are moved through the secretory cells by highly specific cell surface receptor groups. Our overall goal is to learn more about the transport mechanism so that we can determine which areas may ultimately be manipulated to increase calf survivability; the present project is one important step in achieving this overall goal. We intend to use recombinant DNA techniques to develop DNA probes for the bovine immunoglobulin receptor, which is of central importance to immunoglobulin transport. These DNA probes will be used in later studies on this essential mechanism.

Genetic engineering *will* have an impact on the dairy industry. The potential is great, but the realization of that potential will come only after considerably more research. Few short-term "payoffs" exist; we are looking instead toward long-term needs with the conviction that genetic engineering will someday be a real benefit to the dairy industry.

Update on Embryo Transfer Research

CHARLES N. GRAVES AND STANLEY F. HUELS

It is estimated that in 1982, more than 30,000 calves in North America will have been born from embryo transfer. Next year the number will undoubtedly be much higher. The increasing use of embryo transfer as a tool for genetic improvement has depended and will continue to depend on research carried out by both embryo transfer units and research organizations such as state universities.

Previous experiments by Illinois researchers have shown that 1) for superovulation of dairy cows, the use of follicle stimulating hormone (FSH) results in more ovulated oocytes (eggs) and the subsequent recovery of more embryos than does the use of pregnant mare serum gonadotropin, and 2) a cow may be superovulated several times without showing a decrease in the number of ovulated oocytes and recovered embryos.

More recent experiments have attempted to increase the ovulatory response of a cow at the time of superovulation and to decrease the variability in the number of oocytes ovulated during subsequent superovulation treatments of the same cow, as well as to decrease the variability of response between cows. In these experiments, the FSH was administered either twice daily in water, once daily in a mixture of 3.2 percent gelatin, or twice daily in a mixture containing luteinizing hormone (LH) added at 20 percent of the FSH level. Workers in Louisiana have reported that gelatin retards the dissolution of FSH after it is injected and so makes the FSH more effective. The LH was added because it is known that follicular growth occurs in cows when detectable levels of LH are present. Two different FSH preparations were used in the LH treatments: a highly purified preparation produced by Reheis Chemical Company, and a less purified preparation produced by Burns-Biotec Laboratories, Inc

The results of these experiments indicate that gelatin is not a good carrier for FSH. In the gelatin treatment, a mean of only 3.4 oocytes were ovulated per cow (as detected by palpation of the ovaries for corpora lutea), and a mean of 1.1 embryos were recovered per cow per superovulation attempt. This response was less than 50 percent that observed when the FSH was administered twice daily in water. When LH was added to the FSH preparation, the mean number of ovulations for the cows subjected to the more highly purified FSH plus 20 percent LH was 9.3, as compared to 15.4 ovulations for the less purified preparation. The mean number of recovered embryos for the two groups was 6.1 and 11.9, respectively. The less purified preparation is apparently broken down more slowly and thus remains active over a longer time period.

Other experiments tested the effect of catheter position on the percentage of embryos recovered (Table 1). It was found that when the end of the flushing catheter was located approximately 7.5 centimeters from the utero-oviducal junction, the recovery rate of the embryos was much higher (74 percent) than when the end of the flushing catheter was located more than 7.5 centimeters from the utero-oviducal junction (46 percent). The location of the catheter within the uterine horn also influenced the amount of fluid required to recover a satisfactory number of embryos. When the flushing catheter was placed within 7.5 centimeters of the utero-oviducal junction, most of the embryos were located in the first two 125-milliliter fractions of flushing medium. When the catheter was placed more than 7.5 centimeters from the junction, many embryos were found in the third fraction or were left in the uterine horn. The flushing device used in these studies was a Franklin bovine egg collection tube. Although the data are only true for this flushing device, other flushing devices have similar characteristics.

Since it is difficult to locate and isolate embryos when a large volume of flushing medium is used, different methods of isolating embryos from the flushing medium were also investigated. Bovine embryos were added to a flushing medium previously used to flush embryos, and the embryos were then recovered by different procedures. The settling procedure produced the best results. In this procedure, the embryos were allowed to settle in the flushing medium for 15 minutes, and the lower 35 milliliters of medium was then removed and searched. In 50 trials, all but one of the embryos were recovered in the bottom

Table 1. Effect of Catheter Position on Embryo Recovery

Position of catheter end	Number of uterine horns flushed	Percentage of embryos recovered	Percentage of embryos recovered in each fraction: First fraction	Second fraction	Third fraction
Less than 7.5 centimeters from utero-oviducal junction	55	74.2	58.1	33.4	8.5
More than 7.5 centimeters from utero-oviducal junction	15	46.1	38.3	36.3	25.4

fraction, and that embryo, when isolated from the upper fraction, was fragmented and degenerated. Recovering the embryos by filtration and centrifugation was less successful. In the filtration trials, the flushing medium and embryos were poured through a 74-micron mesh filter. The embryos were then recovered after either dipping the filter in medium or inverting the filter and forcing medium through it. In the centrifugation trials, the embryos were placed on a sucrose or ficoll gradient and centrifuged at 50 to 500 gravity forces for various time intervals. None of the recovery procedures was successful in separating the embryos from cellular debris, although both filtration and centrifugation removed blood and noncellular components.

Research efforts are presently being directed toward embryo freezing, embryo sexing, and micromanipulative procedures. Freezing embryos and then transferring them using on-the-farm nonsurgical procedures would greatly reduce the cost of embryo transfer because it would eliminate the necessity of maintaining large numbers of recipient heifers. Sexing embryos before they are transferred is an expensive, time-consuming process that diagnoses the sex correctly only 60 to 70 percent of the time. Investigators are now using the H-Y antibody, present only in male tissue, to develop a fast, accurate, and inexpensive procedure for sexing. Splitting embryos to obtain multiple identical offspring, fertilizing oocytes in test tubes (*in vitro* fertilization), microinjecting a single sperm into an oocyte, and microsurgically removing the male or female genetic component of the embryo and injecting other components in its place are all techniques that are now being performed—but only on a very limited scale and primarily in laboratory animals. Exciting times are ahead in this area.

Reestablishing Reproductive Cycles in the Early Postpartum Cow

MICHAEL R. BELL AND J. ROBERT LODGE

One of the primary problems of the dairy producer is how to achieve conception in cows within a reasonable period of time following calving. For conception to occur, the cow must be having normal estrous cycles that are accompanied by identifiable signs of heat. Several investigators have reported that the use of gonadotropin releasing hormone (GnRH) at 14 days after parturition initiates ovulation in a high percentage of cows. It is also known that massaging the reproductive tract through the rectum, as is done during artificial insemination, releases hormones and so stimulates uterine activity.

An experiment was designed to study the effect of GnRH injection and reproductive tract massage on the initiation of ovarian activity in the early postpartum dairy cow. First-calf heifers and cows that had calved more than once were studied. The cows had calved at the University of Illinois dairy farm between September 1, 1981, and February 1, 1982. Animals that had had no complications associated with calving or the first few days following calving were assigned to the experiment on the 8th day postpartum. The cows were placed into the following three groups of 16 animals each: GnRH, massage, and control. The experiment was continued until 50 days after calving. The cows in the GnRH-treatment group received a

single intramuscular injection of 100 micrograms of synthetic GnRH on day 14 postpartum. The cows in the massage group received a gentle, continuous massage of the cervix through the rectum for three minutes each day on days 12, 13, and 14 postpartum. The cows in the control group received no treatment. All the animals were housed in free stalls in a single lot. They were observed for 20 minutes twice daily (7:00 a.m. and 6:00 p.m.) for signs of estrus. Tail-head grease paint was used as an aid to heat detection. Digital distance pedometers attached to neckstraps were tested on some cows to measure the relationship of physical activity to estrus and ovulation.

Milk progesterone concentrations were determined on milk samples collected, and the changes in progesterone concentration were used to determine whether ovulation had occurred. The results showed that 14 of the 16 cows in the GnRH group ovulated on an average of 16.4 days following parturition. Five cows ovulated before the GnRH treatment was given. Six cows ovulated on the day following treatment, which was the day that ovulation was expected. Nine of the 12 cows that had sufficient time had a second ovulation during the course of the study. Fourteen of the 16 cows (87.5 percent) in the GnRH group had at least one ovulation before 50 days postpartum.

Thirteen of the 16 cows in the massage group averaged 24.1 days between parturition and their first ovulation. One cow ovulated before the massage treatment was begun. Seven of the 9 cows that had sufficient time had a second ovulation, and 2 out of 3 cows ovulated a third time before 50 days postpartum. Thirteen of the 16 cows (81.2 percent) in the massage group had at least one ovulation before 50 days postpartum.

All but one cow in the control group (93.7 percent) had at least one ovulation during the study. The average time from parturition to first ovulation was 24.1 days. Eleven of the 12 cows that had sufficient time had a second ovulation.

Only 19.7 percent of the ovulations were accompanied by an observed standing heat. About 50 percent of the total ovulations were accompanied by some observable sign of estrus. Seventy percent of the cows that were fitted with pedometers showed evidence of increased activity associated with ovulation. Seventy-three percent of these cows also showed a decreased daily milk production associated with estrus and ovulation.

In summary, injecting GnRH at 14 days postpartum did shorten the average time to first ovulation, and massaging the reproductive tract had no effect in comparison to controls. Significantly, neither treatment increased the total number of ovulations as compared to the controls. One can conclude from the results of this study, which involved a relatively small number of cows, that there is no advantage to treating normal postpartum cows with GnRH.

Use of Supplemental Niacin

EDWIN H. JASTER

During early lactation, the combined effects of slowly increasing dry matter intake, high milk production, and decreasing body weight impose a severe metabolic stress on the high-producing dairy cow. Approximately one-half of the cows in high-producing herds experience borderline ketosis during early lactation. Adding niacin to ruminant rations has improved milk production and milk persistency, has stimulated protein synthesis by rumen microorganisms and has improved the adaptation of beef cattle to feed lots. This field trial was conducted to obtain information on the effect of niacin on milk and fat production in six commercial dairy herds in Stephenson County, Illinois. Dairy cows in each herd were paired by lactation number and previously completed 305-day milk production. Paired animals were allotted randomly to one of two groups (niacin or control). Each cow at calving was scored for body condition on a 1-to-5 scale (1 = thin; 5 = fat). The niacin group received once daily a premix containing 6 grams of niacin, 5 grams of molasses, and 19 grams of wheat middlings during the first 10 weeks postpartum. The control group received a placebo premix of 5 grams of molasses and 25 grams of wheat middlings. Milk production was recorded weekly, and milk fat was measured monthly by the Dairy Herd Improvement Association (DHIA).

Additions of 6 grams of supplemental niacin per cow per day in early lactation did not ncrease milk production or milk fat percentage (Table 1). Lactation number and body con-.ition at parturition were similar for both treatments. Milk production peaked earlier postpartum in the niacin group (weeks 3 to 4) than in the control group (week 5)—see Figure 1. However, control cows peaked at higher levels of milk production than cows that received niacin (74.8 versus 72.6 pounds of milk).

Table 1. Effect of Supplemental Niacin on Certain Milk Factors during the First 10 Weeks Postpartum

Variables	Niacin treatment	Control treatment
Number of cows	156	161
Milk production (lb/day)	68.6	68.4
Milk fat (%)	3.7	3.6
4% FCM (lb/day)[a]	66.7	66.4
Lactation number	3.1	3.1
Body condition[b]	3.1	3.1

[a]Fat-corrected milk.
[b]Scored from 1 to 5; 1 = thin, 5 = fat.

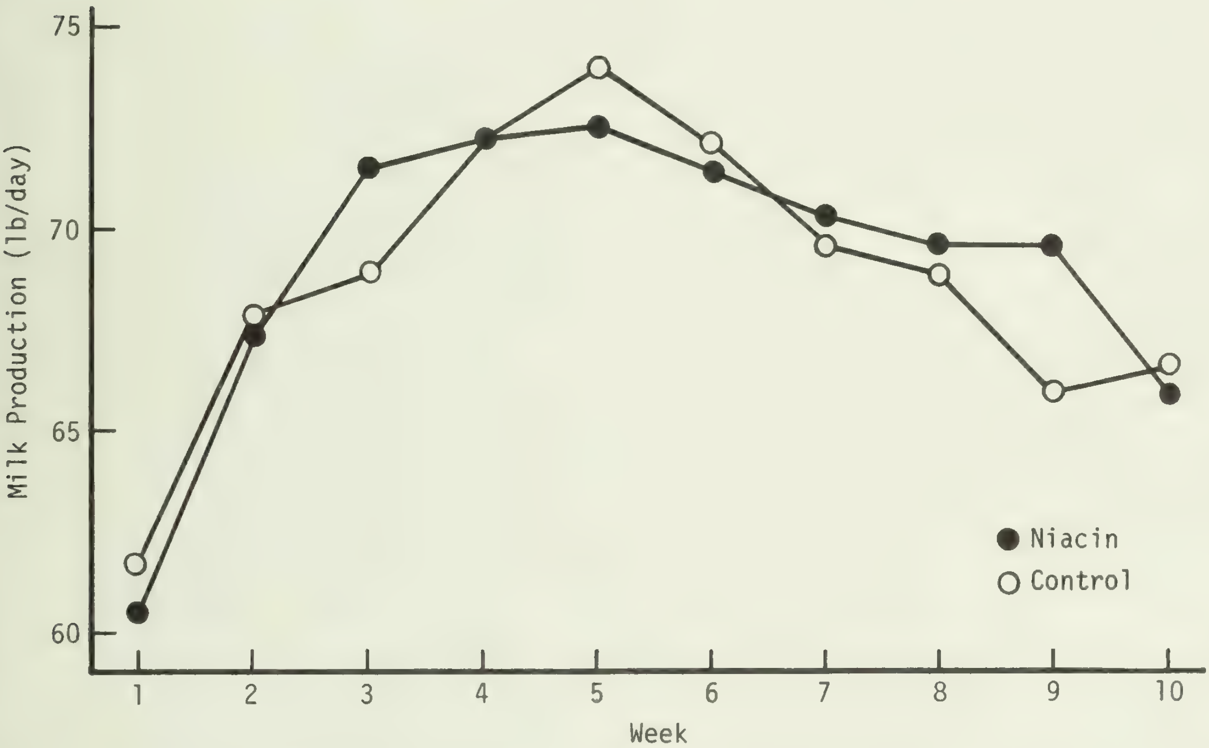


Figure 1. Effect of supplemental niacin on milk production during the first 10 week postpartum.

High-producing (over 60 pounds per day), first-lactation heifers that received niacin produced more milk during the first 10 weeks postpartum than controls (Table 2). Milk fat and body condition at parturition were similar for both groups. First-calf heifers with milk production over 60 pounds per day that received niacin produced more milk and had higher milk production peaks than did controls (Figure 2). However, milk production was about the same when all first-calf heifers were analyzed (Figure 3). All first-calf heifers receiving niacin reached peak production before controls (weeks 3 to 4, as compared to week 6), but they did not peak at higher levels of milk production.

Supplementing rations with niacin (6 grams per day) during early lactation improved milk production in high-producing, first-calf heifers—possibly because it reduced subclinical ketosis. However, niacin supplements did not significantly alter milk production or milk fat concentration when all cows in the study were analyzed. Additional work is needed

to substantiate these preliminary results, to establish when niacin should be fed during lactation, and to determine its value for preventing ketosis and increasing milk production.

Table 2. Effect of Supplemental Niacin on Certain Milk Factors in First-Lactation Heifers Producing More than 60 Pounds per Day of Milk during the First 10 Weeks Postpartum

Variables	Niacin treatment	Control treatment
Number of cows	13	12
Milk production (lb/day)	70.0	66.4
Milk fat (%)	3.6	3.6
4% FCM (lb/day)[a]	67.5	63.8
Body condition[b]	3.0	3.0

[a]Fat-corrected milk.
[b]Scored from 1 to 5: 1 = thin; 5 = fat.

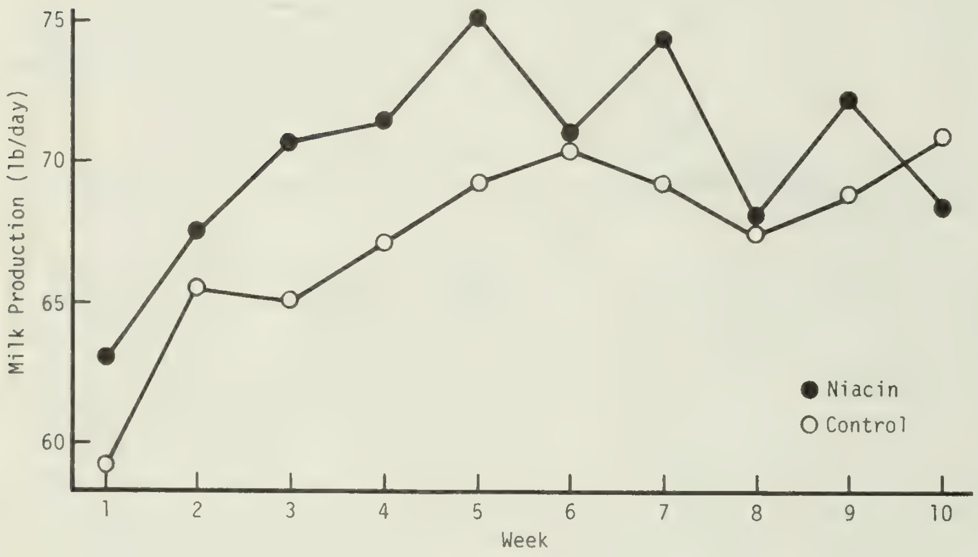


Figure 2.

Effect of supplemental niacin on milk production of first-lactation heifers producing more than 60 pounds of milk per day during the first 10 weeks postpartum.

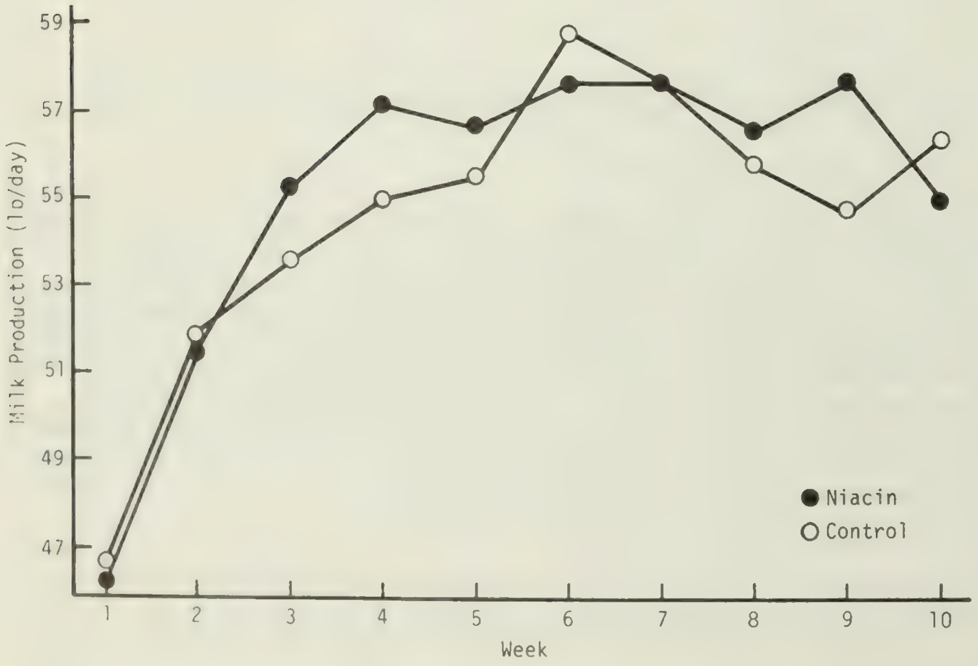


Figure 3.

Effect of supplemental niacin on milk production of first-lactation heifers during the first 10 weeks postpartum.

1984
Illinois Dairy Report

Department of Dairy Science
Cooperative Extension Service
Agricultural Experiment Station
College of Agriculture
University of Illinois at Urbana-Champaign

Searching for Hidden Dollars

1984 Illinois Dairy Days

January	9	Kankakee, Extension Office
	10	Marengo, Shady Lane Restaurant
	11	Freeport, Masonic Temple
	11	Elizabeth, Community Building
	12	Sterling, Emerald Hill County Club
January	13	Pekin, Agriculture Center
	17	Quincy, Farm Bureau Building
	18	St. Libory, American Legion Hall
	19	Breese, American Legion Hall
	20	Effingham, Extension Center

Authors

Department of Dairy Science, University of Illinois at Urbana-Champaign, except as noted

JIMMY H. CLARK, professor, nutrition

CARL L. DAVIS, professor, nutrition

DEWAYNE E. DILL, research assistant, management

TOM R. DRENDEL, former research assistant, nutrition

GEORGE C. FAHEY, Jr., associate professor, Department of Animal Science

RANJIT S. FERNANDO, research associate, management

CHARLES M. FISHER, research assistant, management

DANIEL G. GIACOMINI, research assistant, nutrition

W.R. (REG) GOMES, professor, reproductive physiology, and department head

CHARLES N. GRAVES, associate professor, reproductive physiology

GARY W. HARPESTAD, associate professor, Extension dairyman

E. EVERETT HATFIELD, professor emeritus, Department of Animal Science

MICHAEL F. HUTJENS, professor, Extension dairyman

EDWIN H. JASTER, assistant professor, management

MARK L. KNIEF, undergraduate student

JAMES B. LEVERICH, research fellow, management

GENE C. McCOY, associate dairy scientist, management

R. DAVID McQUEEN, DVM, professor, College of Veterinary Science

MICHAEL R. MURPHY, assistant professor, nutrition

HOYLE B. PUCKETT, professor, research leader USDA-ARS and Department of Agricultural Engineering

JAMES L. ROBINSON, associate professor, biochemistry

JOHN A. ROGERS, former research assistant, nutrition

ROGER D. SHANKS, assistant professor, breeding and genetics

MARK S. SIEGEL, former research assistant, physiology

SIDNEY L. SPAHR, professor, dairy science

JERRY W. SPEARS, former research associate, nutrition

PAUL SPENCER, DVM, Bureau of Animal Health, Illinois Department of Agriculture

STEVEN R. SUSLICK, undergraduate student

STEVEN T. WOODFORD, research assistant, nutrition

Contents

1984 THEME: SEARCHING FOR HIDDEN DOLLARS

UNIVERSITY OF ILLINOIS RESEARCH REPORTS

The Department of Dairy Science

W. R. (REG) GOMES

In the United States today, dairy producers are facing a difficult period. To quote Thomas Paine, "These are the times that try men's souls." Specifically, dairy producers encounter a level of production that continues to exceed consumption and a plethora of suggestions for price support adjustments. These suggestions all involve decreased cash income, the prospect of rapidly rising feed prices following the summer drought and the PIK program, and the possibility of continued depression in beef prices, at least in the short term.

We in the Department of Dairy Science are committed to programs designed to help dairy farmers better understand their problems and better adapt to the changing conditions in the dairy industry. This *1984 Illinois Dairy Report* outlines some ways by which dairy production could become more efficient and describes some of the research that provides valuable information for the future. We remain convinced that an aggressive program—one that includes research, teaching, and dissemination of current information—is the greatest contribution we can make to a strong industry.

Our teaching program in Urbana is being updated to meet the current needs of our bright, dedicated students, and our research program continues as one of the finest in the nation. We are proud of our faculty (listed below), our staff and students, and our relationship with the dairy industry of Illinois. In each of these areas, we are ably assisted by our industry advisory committee, which works closely with the department. The members of the committee for 1983-84 are Carl Baumann of Highland, Douglas Block of Pearl City, Myron Erdman of Chenoa, Ray Hess of Hampshire, Roger Marcoot of Greenville, James Meyer of Peotone, Melvin Schweizer of Nokomis, John Sliter of Rosemont, and Richard Vetter of Arlington Heights.

The faculty of the department, the members of the advisory committee, and I welcome your comments, suggestions, and questions. We appreciate your interest in the 1984 Dairy Days program and hope that you will find it useful.

DEPARTMENT OF DAIRY SCIENCE

Faculty	Specialization
Marvin P. Bryant, professor	Ruminant microbiology
Jimmy H. Clark, professor	Dairy cattle nutrition
Raymond G. Cragle, professor	Reproductive physiology
Carl L. Davis, professor	Dairy cattle nutrition
Charles N. Graves, associate professor	Reproductive physiology
W. R. (Reg) Gomes, professor and department head	Reproductive physiology
Michael Grossman, associate professor	Dairy breeding and genetics
Gerhard W. Harpestad, associate professor	Extension dairyman
Robert B. Hespell, associate professor	Ruminant microbiology
Walter L. Hurley, assistant professor	Lactation endocrinology
Michael F. Hutjens, professor	Extension dairyman
Edwin H. Jaster, assistant professor	Dairy cattle management
Ralph V. Johnson, associate professor	Extension dairyman
Bruce L. Larson, professor	Biochemistry and lactation
J. Robert Lodge, professor	Reproductive physiology
Gene C. McCoy, farm manager	Dairy cattle management
Michael R. Murphy, assistant professor	Dairy cattle nutrition
James L. Robinson, associate professor	Biochemistry
Roger D. Shanks, assistant professor	Dairy breeding and genetics
Sidney L. Spahr, professor	Dairy cattle management

Forage Options and Opportunities

MICHAEL F. HUTJENS

Your forage program may be one of the factors that will determine whether you survive the 1983-84 dairy squeeze. Several important "forage facts" are listed below.

- Fifty to 100 percent of the dairy ration consists of forage.
- Forages in 1982 cost $370 per cow and her replacement annually.
- Hay prices vary from $60 (typically in June) to $150 a ton in winter.
- Top quality forage dry matter can replace 15 to 25 percent of grain in a feeding program.
- Silage continues to replace hay and pasture among Midwest dairy herds.

Table 1. Feed Amounts at Various Milk Production Levels (Minnesota)

	Milk yield (lb)		
	12,500	15,500	20,954
	DM, tons annually		
Hay	1.7	1.6	1.8
Haylage	1.1	1.4	1.9
Corn silage	1.2	1.2	0.7
Grain	2.6	2.8	3.5

FORAGE QUALITY

As cows produce over 20,000 pounds of milk annually, meeting their nutrient needs becomes critical. High quality forage results in greater dry matter intake, high nutrient level per pound of dry matter, and increased digestibility. Producers must raise, store, and feed top quality forage if they are going to be successful in keeping feed costs down (Table 2).

Table 2. Changes in Feed Composition of Alfalfa with Advancing Maturity (Wisconsin)

	Standing crop					Crop as fed				
Stage of maturity	DE[a]	CP[b]	NDF[c]	Intake[d]	Milk yield	DE[a]	CP[b]	NDF[c]	Intake[d]	Milk yield
	percent			*pounds*		*percent*			*pounds*	
Mid-bud	71	24	37	45	68	64	21	40	42	53
First bloom	67	20	41	37	48	61	18	44	35	36
Mid-bloom	64	18	48	34	36	57	16	51	29	21
Full bloom	62	16	53	28	23	54	14	56	25	12

[a]Digestible energy.
[b]Crude protein.
[c]Neutral detergent fiber.
[d]Dry matter intake.

A number of conditions will influence the nutrients available to the dairy cow. Cut the plant when feed value is high. (For example, cut alfalfa in early bloom when protein is over 20 percent, and finish when alfalfa is in mid-bloom.) Some producers try to complete forage harvest in six days. Keep in mind the following facts:

- Protein values in legumes can drop by 0.5 percentage point *each day* that harvest is delayed beyond optimal maturity.
- Forage plants continue to respire until moisture content drops below 40 percent, consuming 2 to 16 percent of the plant dry matter. Greater losses occur during poor drying conditions.
- Hay-making losses can vary from 15 to 30 percent of the total dry matter: 1 to 6 percent in cutting, 1 to 4 percent in conditioning, 5 to 15 percent in raking, and 3 to 8 percent in baling.

● Field dry matter losses from undried windrowed hay increase 3.5 percent per inch of rain, with losses for drier hay being higher.

The key consideration becomes matching the forage program to feed requirements and to the acreage available (Table 3).

Table 3. Expected Dry Matter Losses in Forage Harvesting, Storing, and Feeding[a]

Method	Dry matter losses: Harvest %	storage %	feeding %	total %	Field tonnage to obtain 1 ton effectively fed[b]
Hay, conventional bale					
Rained on	32.6	4.0	5.2	41.8	1.63
Average	25.0	3.8	5.2	34.0	1.46
No rain	17.4	3.6	5.2	26.2	1.32
Barn dried	13.4	1.8	5.2	20.4	1.24
Large packages					
Field cured	25.0	14.2	15.3	54.5	1.83
Acid treated	15.0	10.7	5.5	31.2	1.39
Hay crop silage moisture					
70+	2.0	21.2	11.0	34.2	1.45
60-69	5.0	10.1	11.0	26.1	1.32
Under 60	11.5	8.2	11.0	30.7	1.38
Corn silage moisture					
70+	4.0	13.7	4.0	21.7	1.26
60-69	5.0	6.3	4.0	15.3	1.17
Under 60	16.2	6.3	4.0	26.5	1.33

[a]SOURCE: *Hoard's Dairyman Chore Reduction Bulletin.*
[b]Tonnage needed to be grown for one ton of material fed to the animal.

MOISTURE LEVELS IN HAYLAGE

The major discussions concerning moisture levels for ensiling haylage have centered on field losses and the storage unit. Recently, Wisconsin researchers explored the effect of wilting and ensiling on the redistribution of nitrogen (protein) when the dry matter content of the silage varied (Table 4).

Table 4. Changes in Composition of Alfalfa Forage from Wilting and Ensiling

Dry matter (%)	Fresh forage 20.8	Ensiled forage 29	40	66	Hay 85
		Dry matter, percent			
Crude protein	19	20.1	20.3	19.5	17.3
Lactic acid	...	2.5	4.4	0.4	...
Acetic acid	...	2.1	1.0	0.2	...
pH	...	5.0	4.6	5.4	...
		Total nitrogen, percent			
Soluble nitrogen	41.3	72.1	64.1	42.3	32.1
Ammonia nitrogen	...	14.1	7.0	4.4	...
ADIN	5.3	7.9	7.5	12.9	10.4

Wet haylage yielded lower quality protein (less in the form of amino acids), a different amino acid pattern compared to the fresh feed, a greater breakdown of plant nutrients (higher ammonia and acid levels), and more soluble protein. The drier haylage had higher levels of amino acid nitrogen and acid-detergent insoluble nitrogen (ADIN), indicating slight heat damage. ADIN values should be less than 15 percent of the protein (referred to as available protein). Baled hay had the lowest protein content and the most favorable protein-solubility value. Consider the following points if you want top quality haylage.

- At least 10 percent of forage particle size should be over 1 1/2 inches in length. If you have a 1/4 inch theoretical chop, only 7 to 10 percent will be over 1 1/2 inches. A 3/16 inch cut will probably contain no long fiber.
- Cows that spent 600 minutes a day chewing and ruminating had normal fat tests (3.7). Chewing time with finely chopped haylage was 420 minutes and a 3.0 percent fat test.
- Fill the silo fast with at least four loads a day to avoid surface spoilage.
- A silo distributor improves packing and fermentation.

CHEMICAL HAY-DRYING AGENTS

Hay remains a popular dairy forage in the Midwest. It is simple to handle and does not require large investments in machinery or storage units. However, field losses and weather risks are major drawbacks. Hay requires long drying times, which results in lower forage quality.

Three key factors influence the drying rate of forages: (1) environmental conditions (humidity, soil moisture, temperature, wind speed, sunlight, and precipitation); (2) harvest management (conditioning and size of windrow); and (3) forage characteristics.

In forage, water is lost from the plant through pores (stomata) that are mainly on the leaves, from the outer cell wall, and during transfer from stem to leaf. Alfalfa loses about 35 percent of stem water by this last route, which reduces stem moisture to about 40 percent. The cell wall can be chemically treated by spraying the crop to improve the drying rate. The waxy cutin layer of the outer stem cell wall is thus broken down so that moisture can escape. The drying rate of the stem becomes about the same as the leaf-drying rate. Drying agents are applied at the time of cutting. A push bar located eight to ten inches abo the cutting level pushes the plant tops over so the spray is directed at the stems. The spray bar is mounted ahead of the cutting reel. Potassium carbonate or sodium carbonate are effective drying agents when used with methyl esters and emulsifying agents (Table 5).

Table 5. Influence of Chemicals That Hasten Drying of Cut Alfalfa

Treatment	Time to 75% D.M. (hours)
None	Over 51
Potassium carbonate (K_2CO_3)	34
Methyl ester + emulsifying agent	38
K_2CO_3 + methyl ester + emulsifying agent	21

Under optimal conditions, the use of chemicals reduced drying time by one day. In addition, limited research indicates that hay quality improved (2.8 percent more soluble carbohydrate), and dry matter losses were reduced (4.4 percent more dry matter).

When considering chemical conditioning, keep in mind the following:

1. Cost will range from $2.60 to $10 per ton of treated hay. If the producer can lower crop losses by 10 percent, the treatment can be cost-effective.

2. The chemical solution consists of soluble powder (8.5 pounds) applied in 15 to 30 gallons of water per ton of dry hay (20 percent moisture). Using large volumes of water resulted in the most effective drying responses. The amount of liquid is as important as the concentration and gives a uniform application.

3. Roll conditioners improved treatment results as compared with flail-type conditioners.

Hay growers need to keep in touch with the latest research as data are obtained under different drying conditions and hay-making techniques.

PDATE ON BIG BALES

Making silage in big round bales (called balage) is a new practice in the Midwest. It llows producers to make silage when weather does not cooperate, uses existing equipment, nd costs $5 to $6 per ton for materials. Bales are rolled up when moisture levels are 0-65 percent. Kentucky researchers report success with alfalfa and fescue. Penn State orkers, however, were concerned that: molding occurred in drier balage (30 to 50 percent oisture); wind could whip bags, which are 3 to 5 mil thick, and break the seal; and that attle had difficulty pulling the forage out of the bale. Getting a dense, tight bale (10 ounds per cubic foot) is critical. Furthermore, adding anhydrous ammonia or propionic acid ay control mold growth. Black bags tend to weather better outside, but become warm in high emperatures. White bags have been improved with ultraviolet inhibitors that stop light rom breaking down the plastic. Bags can be reused if they are not torn.

Big, round bales can lose 15 to 45 percent of their feed value when left exposed to the eather. One alternative is to use a device that wraps the bale with three thicknesses of piral black plastic at a cost of $2.28 to $3.33 for plastic per bale. Plastic slip-on leeves are also available for large round bales.

Purdue workers developed a table to determine the economics of storing bales indoors Table 6).

Table 6. Losses That Justify Building Hay Storage

Hay price ($/ton)	Additional losses due to outside storage (%) 10	20	30
		value of loss ($/ton)	
60	6*	12*	18
80	8*	16	24
100	10	20	30
120	12	24	26

*Not economical with new storage.

The weathered portions of grass hay were 16.3 percentage units lower in TDN. Wisconsin esearchers recommend that big bales be 3 to 4 percent drier than rectangular bales to avoid old damage.

ORAGE PRESERVATIVES

A 1980 national dairy survey reported that 23.7 percent of the farms used a commercial ilage preservative, 59 percent of which treated corn silage, 51 percent hay silage, and 3 percent high moisture corn. When using preservatives, dairy producers often ask these uestions: Which product? When should it be added? Will it be beneficial? Preservatives re usually designed to (a) inhibit undesirable bacterial and mold activity, or (b) promote he type of fermentation desired (Figure 1). Preservatives can be divided into two categor-es: (1) *Fermentation stimulants* include bacteria that direct the fermentation and rapidly educe the pH to preserve the feed. Enzyme additives break down the plant's carbohydrate, aking nutrients available for fermentation. (2) *Fermentation inhibitors* consist of acids nd other products that inhibit bacteria growth and metabolism. Propionic acid, formic acid-ormaldehyde mixtures, blends of propionic acid and acetic acid, diacetate, and salts of eak acids are examples of inhibitors.

Additives are substances which, when added to silage, improve its nutritional value onsiderably. Cereal grains, dried whey, and molasses provide a source of readily ferment-ble carbohydrate. Limestone provides calcium and neutralizes the organic acids produced uring fermentation, thereby extending the process of fermentation. Fortifying with itrogen (such as ammonia or urea) increases protein equivalence in the silage, extends fer-entations, and improves the fermentation pattern.

When excessively wet silage is ensiled, it may benefit from microbial inoculant if ufficient numbers of desirable bacteria (such as lactobacilli) are not present to dominate ver undesirable organisms. Researchers in Kentucky suggested that the culture needs to be

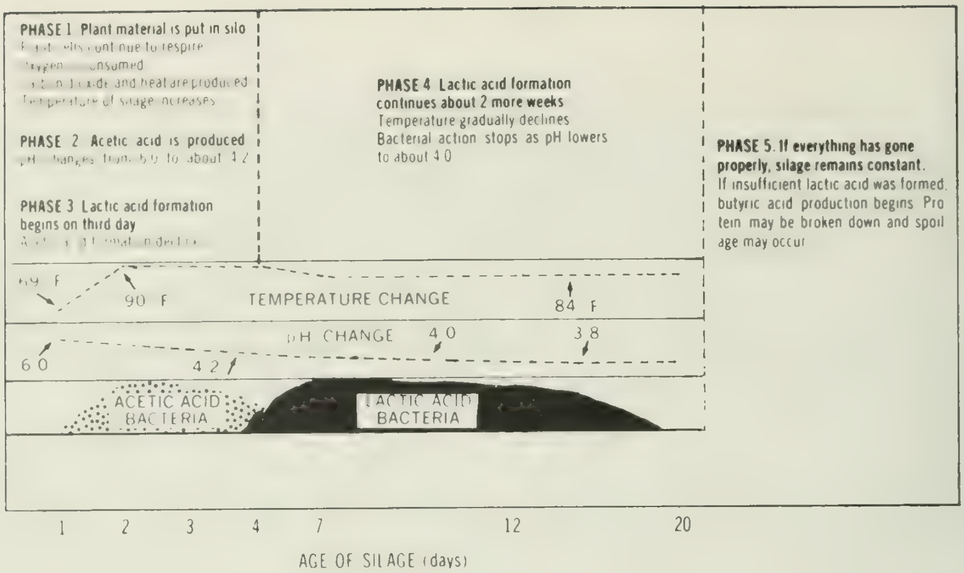


Figure 1. A schematic representation of a normal ensiling process.
SOURCE: Iowa State University, Pm-417 (rev.), 1970.

added at the rate of 100,000 per gram. If legume grass silage is too mature, adding a carbohydrate source (such as ground corn or molasses) can provide fermentable material. Dry silage can benefit from mold and heat-inhibiting preservatives.

Harvesting hay with moisture above 25 percent results in mold growth and high temperature. Minnesota researchers recommend compounds containing more than 60 percent propionic acid applied at the rates of 10 to 30 pounds per ton of hay, as moisture levels increase from 20 to 35 percent. Researchers in New Mexico reported difficulty with uniform application of dry products on hay. At Purdue, bales with 32 percent moisture were treated by injecting anhydrous ammonia or ammonia gas at the rate of one percent by weight in plastic enclosed stacks. Ammonium isobutyrate and propionic acid plus formaldehyde have been effective.

When deciding if a preservative or additive is needed, ask these questions.

- Why do I need to add a preservative or additive this year?
- How does the product work?
- Will it work for my situation?
- Are levels adequate?
- What are the research results?
- Will I recover my investment?

FEEDING DROUGHT-STRESSED CORN SILAGE

Nutrient variation characterizes stressed corn silage. The following corn silage has this nutrient value:

	D.M.	Crude protein	ADF	TDN
		percent		
Barren stalks	22-40	10.9	24-36	60-68
Normal	30-35	8.4	24	68

Energy content will vary from 70 to 100 percent of normal corn silage. To get an estimation of energy content, conduct an acid-detergent fiber (ADF) analysis. Enter your ADF values (on a 100 percent dry matter basis) in one of the equations below.

$$TDN\ (\%) = 87.84 - (0.7 \times \%\ ADF)$$
$$\text{Net Energy-Lactation (Mcal/lb)} = 1.044 - (0.131 \times \%\ ADF)$$

Extra grain will be needed to replace energy shortages unless the stressed corn is fed to heifers and low-producing cows. Supplemental vitamin A (50,000 units for an adult cow per day) will guard against low carotene levels and against interference of carotene conversion to vitamin A by nitrates. Nitrate levels in the total ration dry matter (including grain, hay, and all other feeds) should be below 0.5 percent or 5,000 parts per million. Palatability of the corn silage can be reduced by dry silage, coarse chopping, poor fermentation, or mold.

COMPUTERIZED RATION FORMULATION

Two IBM computer dairy ration programs are available in some county and area offices and at the dairy science Extension office. The Illinois program will evaluate your existing feed program and make ration adjustments. The Michigan program is a least-cost program that can balance milk cows (young and mature cows), dry cows, and heifers, considering 20 different variables. The current charge is $10 per farm evaluation.

Managing Your Profit Margin

W. R. (REG) GOMES

As 1983 draws to a close and we attempt to predict the short- and long-term future of the dairy industry, it is painfully apparent that things will get worse before they get better! Nonetheless, we are convinced that the dairy situation will get better for those who carefully manage their shrinking profit margins and remain in our important industry.

THE PROBLEM

The Agricultural Act of 1949 provided for milk to be supported from 75 to 90 percent of parity, adjusted annually. The dairy program was intended to assure an adequate supply of wholesome dairy products at reasonable prices to consumers. In 1977, the minimum level of support prices was increased to 80 percent of parity with provision for semiannual adjustments. Shortly thereafter, the prices of feed grains began to decrease, as did the markets for beef and pork. This meant that raising and feeding dairy cattle was relatively more profitable (or involved fewer losses) than other enterprises. The national dairy herd therefore grew, and the supply of milk increased. As a result of grain embargoes, which led to more "cheap" feed, and increased imports of products that reduced utilization of the domestic milk supply, a "dairy surplus" problem came into existence. Government purchases of dairy products began to increase and continue to do so today.

In 1981, the increase in support price scheduled for April 1 of that year was cancelled and the support price was frozen at $13.10 for 1981 and 1982. In spite of that action, government purchases of dairy products increased for the third consecutive year, and government expenditures from the program went over the $2 billion mark (Table 1).

In 1982, Congress authorized an assessment and refund program for the dairy industry. The first assessment of 50 cents per hundredweight, though delayed by litigation and court decisions, went into effect in spring, 1983, in spite of arguments by many in the dairy community that this "tax" would serve to increase—not reduce—milk production. A second assessment, also 50 cents per hundredweight, has now gone into effect; this assessment has a proviso for refunding the charge to those producers who can document a decrease in production of approximately 8.5 percent.

Table 1. Milk Production and Government Acquisition, 1978-1983[a]

Year	Cow numbers	Milk production	Support price	Government acquisition
	billions	*billion lb*	*$/cwt.*	*$ billion*
1978	10.90	121.46	9.43	0.45
1979	10.79	123.41	10.76	0.27
1980	10.78	128.52	12.36	1.01
1981	10.86	133.01	13.10	1.89
1982	11.01	135.80	13.10	2.18
1983*	11.06	138.52	13.10**	2.70

*Estimated
**Two $0.50 assessments did not lower the legal support price.
[a]Data supplied by H. D. Guither, Extension Economist, University of Illinois.

At the time this paper goes to press, several alternatives seem possible. Advisors to the Secretary of Agriculture and the Congress suggest that dairy producers would support a paid diversion or "dairy PIK" program: this plan would call for paying dairy producers $10 for each hundredweight reduction in milk production. Other commodity groups (National Cattlemen's Association, National Pork Producers Association) have opposed the proposal and the Secretary of Agriculture has linked it to other controversial farm legislation.

The primary alternative to the paid diversion program is a further series of assessments, which may total as much as $1.50 per hundredweight, or a direct reduction in the price support level.

To further cloud the issue of profit margins in the dairy industry, the 1983 PIK program for grain crops coincided with a drought-induced reduction in yields. These developments have caused a rapid drawing-down of beef herds, so that the dairy industry faces sharply higher feed costs, reduced beef prices (at least in the near future), and decreased income from milk. Undoubtedly, many producers will be caught in the price squeeze, and those remaining will face a serious problem in managing a rapidly shrinking profit margin. Already the average dairy producer in Illinois is losing money (Table 2).

The question then becomes, how does the Illinois dairy producer manage this decreasing margin of profit to survive the impending price squeeze?

KNOW YOUR COSTS

The data in Table 2 show that the average dairy farmer in Illinois is already losing money— and has done so for nine of the last eleven years. Many have remained in business by working for a subsistence income, by subsidizing the dairy enterprise with other farm income or with an outside job, or by eroding the value of the operation through depreciation of capital holdings. During the same period, efficient and knowledgeable producers have been able to make a real profit on their dairy operations.

In order to exist in the tighter market of the next few years, it is essential that producers be aware of the real costs of production; that they carefully analyze their farm operations and calculate the break-even point for each changing variable of cost and income. In a recent article in *Hoard's Dairyman* (August 10, 1983), agricultural economists at Michigan State University presented a method for calculating the break-even point of return to management and investment (Table 3). Of course, this model should be adjusted to reflect actual on-farm expense and income items.

Table 2. Cost of Producing Milk and Milk Prices for Illinois, 1973-1983[a]

Year	Cost per cwt.	Price per cwt.	Net
1973	6.82	6.53	-0.29
1975	9.70	7.97	-1.73
1977	9.34	9.18	-0.16
1979	11.50	11.68	0.18
1981	14.12	13.19	-0.93
1983*	14.50	12.60	-1.90

*Estimated
[a]SOURCE: D. F. Wilken, Agricultural Economist, University of Illinois.

Table 3. The Burghardt-Fenner Model for Calculating Break-Even Point[a]

A. Expected 1983 income and expenses*

	Example	Your farm
Revenue		
Milk (145 cwt. @ $13.50/cwt.)	$117,600	$
Dairy cattle	11,100	
Crop sales	12,000	
Other	3,300	
Total revenue	$144,000	$
Variable costs		
Hired labor	$ 12,000	$
Feed	22,500	
Machinery repair	6,300	
Fuel and oil	6,000	
Crop expenses	16,200	
Vet and breeding	3,900	
Marketing	5,100	
Supplies	3,000	
Utilities	3,300	
Other	5,100	
Total variable costs	$ 83,400	$
Fixed costs		
Interest	$ 13,200	$
Rent	3,900	
Insurance	1,500	
Real estate taxes	3,900	
Building repairs	2,100	
Lease payments	3,000	
Depreciation	21,000	
Total fixed costs	48,600	$
Total production costs	132,000	
Net farm income before tax	$ 12,000	$

*60 cows producing 14,500 M.

B. To determine break-even herd size

		Example	Your farm
Step 1:	Determine contribution margin per cow		
	Total revenue per cow ($144,000 ÷ 60)	$2,400	
Less:	Total variable costs per cow ($83,400 ÷ 60)	$1,390	
	Contribution margin per cow	$1,010	
Step 2:	Determine break-even number of cows Total fixed costs divided by contribution margin per cow ($48,600 ÷ $1,010) equals	48 cows	

[a]*Hoard's Dairyman*, August 10, 1983, p. 961.

The use of the break-even model or any other accounting scheme that allows the producer to evaluate production efficiency depends upon accurate, up-to-date financial records. Without knowing the profit margin, producers may find it impossible to manage.

PRODUCE MORE EFFICIENTLY

If a producer is to reduce production to take advantage of refundable assessments or paid diversion programs, it is imperative that the remaining animals produce milk more efficiently so that the profit margin per cow will be enough to keep the operation alive. To attain the maximum profit margin, the very best in farm management techniques will be essential. They include the following:

Records. These should include not only expense and income figures, but records of production (for most, DHIA is still a "best buy"), reproduction, and health.

Culling. If efficiency in a smaller operation is the key to survival, animals must be culled heavily. On the basis of the records described above, those animals that will not pay their way every year must be eliminated. As the cost squeeze narrows profit margins, even harder choices must be made.

Animal health. Each producer must make decisions regarding on-farm health programs. Is a contracted herd health program the least expensive— in terms of actual cash outlay and saved production and animals— or is another system equally profitable? Depending upon the management skills available on the farm, either choice may be correct, but the correct choice should be made. At what point is an open cow culled rather than rebred? Is this decision made on a profit and loss basis? Are all such decisions made this way?

SPEND MONEY TO MAKE MONEY, BUT SPEND WISELY

Decisions on animal care, culling, and feeding all involve investments and the probable returns from them. The same is true for nearly every decision made concerning the farm operation. Some producers will consider "savings" that could in fact help destroy the operation. For example, the dairy operator who decides to stop— or decides not to start— DHIA testing of the herd, may be without the records essential to important culling and breeding decisions. On the other hand, individual producers may find that less expensive programs (e.g. AM/PM) could both save money and provide needed information.

In other areas, each farm operator must choose between necessities and luxuries, between putting off expenditures and undermining the farm operations. It may be possible to patch up the old barn rather than replace it and get good service for several more years without harming the farm operation; but saving money on semen by buying an inferior bull would usually cost a good deal in terms of genetic progress in the herd.

PREPARE FOR THE FUTURE

Those who survive the crunch and remain in the dairy business will be part of a more efficient, more knowledgeable group of producers. In order to establish the best possible conditions for that industry, individual producers should become familiar with programs that will influence their farms and their industry.

Use educational information. To continue to compete, each of us will have to continue to improve. Much of the information that is now available is not widely used. For example, herds on DHIA test produce, on an average, about 3,000 pounds more milk per cow, but two-thirds of Illinois producers are not on test; Illinois ranks 38th among states in production per cow. Bull proofs are widely advertised and provide good information on bulls that may improve production, yet Illinois ranks 35th in the genetic level (high PD sires) of first-calf heifers. It must be emphasized that the professionals— Extension specialists and other consultants— do not have all the answers, but they can provide up-to-date, important information.

Advertising. It has been said that "in good times, one should advertise; in bad times, one *must* advertise." Several dairy programs, such as the "slice-of-life" cheese promotion

have shown that consumption of dairy products can be enhanced by good advertising programs. It is the responsibility of the producer to support and oversee these programs.

Product quality. In recent years, several developments have occurred that can influence the quality of milk being marketed. Sensitive new assays are available for detecting antibiotics in milk, for measuring udder health (e.g., SCC) and for quantifying milk protein on a routine basis. Bills have been introduced in state legislatures to increase minimum standards of dairy products — a move that proponents claim would improve the flavor of milk. And several manufacturers have begun to offer a bonus for milk with increased solids and protein (end-product pricing) and decreased bacteria or cell counts. After careful evaluation, those programs that will benefit the industry should be enthusiastically supported.

Research. Successful businesses have considered, for many years, that a reasonable research and development (R & D) budget was essential if their organizations were to be competitive. The more conservative of these industries have used 3 percent of their gross income on an R & D budget, whereas the more aggressive average 6 percent.

For many years, the research arm of American agriculture—the land-grant universities—was funded by federal and state governments; the agricultural productivity and efficiency resulting from this support have made the United States preeminent in world agriculture. Today, however, government and industry support research in the experiment stations at a rate of less than 0.3 percent. Since fewer and fewer voters will remain on the farm, and since today's farm programs are a large governmental expense, it is difficult to remind our lawmakers that the real beneficiary of our farm output has always been the consumer.

In several industries and in the dairy industry in several states, producer organizations have authorized check-off programs to support commodity research at their state universities. Is the time coming when Illinois dairy families will have to do the same?

An Update on Effective Herd Health Programs

R. DAVID McQUEEN

Herd health continues to be a key management concern of dairy producers. New disease problems, changes in vaccination programs, and modified management systems require updating of recommendations. Several relevant topics are discussed in this paper.

VACCINATION PROGRAM FOR DAIRY HERDS

BRUCELLOSIS (BANG'S DISEASE)

Vaccinate heifer calves between four to seven months of age, using the new reduced dosage vaccine. This is very important not only for protection, but when selling to other dairy producers, since twenty states now require that all breeding heifers be vaccinated before entry.

IBR-PI$_3$-BVD

Vaccinate at birth or as soon afterwards as possible with an intranasal IBR-PI$_3$ vaccine. Revaccinate at seven to eight months with a modified live intramuscular vaccine. This vaccine should contain IBR-BVD-PI$_3$ if BVD has been diagnosed in the herd. In an outbreak of BVD, a killed BVD vaccine may be used on the adult cows. In an outbreak of IBR, intranasal vaccine is recommended. Annual revaccinations may or may not be needed, depending upon individual herd conditions such as contact with neighboring cattle or at shows, herd additions, or environmental stress.

LEPTOSPIROSIS

Animals should be vaccinated at three months of age or older and then revaccinated annually. Control of *Leptospira hardjo* may require vaccination at three-to-six-month intervals. Vaccines should contain strains known to cause problems in area herds. Multiple strain vaccines probably do not produce as high a level of circulating antibody as single strain vaccines.

VIBRIOSIS

Vaccinate open cows and heifers twice just before breeding and annually thereafter, three weeks before breeding in herds using natural service.

BLACKLEG, MALIGNANT EDEMA, ENTEROTOXEMIA

Vaccinate at approximately three months of age and repeat before breeding age. These clostridial diseases are often responsible for undiagnosed, sudden deaths in growing animals, especially those fed for maximum growth.

ROTA AND CORONA VIRUSES, AND E. COLI

These disease agents cause some cases of scours early in the calf's life. If this is proved to be the case, the specific vaccine should be given to the dry cows starting no later than four to six weeks before calving. It is essential that the calf consume adequate colostrum at birth if the vaccine is to provide passive antibody protection.

PASTEURELLOSIS

This respiratory disease is a big problem in some operations. Generally, response to pasteurella bacterins is not as good as desired. Repeated injections, however, can give some protection. Consider this vaccination if pasteurella species are isolated from tissues gathered during autopsy examinations. If calf respiratory and scour problems are serious, we strongly recommend that you force-feed colostrum early and use calf hutches.

Consider a number of factors when using vaccines, including age for proper immunization, vaccines that can be used on open cows only, and the duration of immunity. Because of the large number of variables involved, a herd vaccination program requires detailed records so that vaccines are given to the proper animal at the correct time to avoid serious vaccination reactions or a decline in herd immunity to nonprotective levels.

In the case of most infections, 85 to 90 percent of a herd must be properly vaccinated to prevent a herd outbreak of that disease. Omissions in the vaccination program due to poor record-keeping, errors, oversights, or attempts to save money may undermine the immune status of the herd.

JOHNE'S DISEASE

Paratuberculosis (Johne's disease) creates a very costly disease problem in some Illinois dairy herds. Results of a Wisconsin study of 1,000 culled cows tested at slaughterhouses showed that the disease was present in 10.8 percent of the cows. Diagnostic laboratory records indicate that Johne's disease has been diagnosed in 137 Illinois cattle herds in 47 counties since 1975. A number of breeds of both dairy and beef cattle have been infected. In some herds only an occasional animal develops clinical symptoms, whereas in other herds several cows are culled each year because of the disease. One Illinois dairy herd is currently losing about two cows per month from the disease. Recently, approval has been received for nine herds to be vaccinated against the disease.

Herds may be infected, yet cows may not show signs of the disease (chronic diarrhea and weight loss). The reason for the infection to remain silent or nonclinical in some herds is not well understood but may be related to the low average age of the cows. In other herds, underfeeding and the stress of calving seem to trigger the onset of symptoms, especially when the percentage of older cows is high. Symptoms and losses also appear to be greater

in infected herds that are confined. This may be related to increased exposure of young calves to manure from infected cows during the first six weeks of life.

Since present health regulations do not require a test for Johne's disease before breeding animals are sold, it is important for cattle owners to be informed about the disease and methods of prevention. The following information, which has been adapted from an article written by Dr. R.S. Merkal, mycobacteriosis research leader at the National Animal Disease Center, Ames, Iowa, should prove useful.

FREQUENCY OF DISEASE, ECONOMIC IMPORTANCE, AND INCREASING OCCURRENCE

Johne's disease has become increasingly widespread in recent years, especially in cattle and goat herds, as more and more animals are kept in close confinement. The disease most frequently is transmitted from herd to herd by the purchase of replacement or breeding animals that though infected do not exhibit signs of the disease. Once Johne's disease is established in a herd, eradication is a very lengthy process. If measures are not taken to check the spread of infection within a herd, almost all the animals will eventually become infected, and a significant number will become clinically ill each year. In many cases the losses will exceed the capacity of the herd to replace itself. At present, no treatment has been found that will eliminate the infection in an animal.

BACTERIOLOGY

The causative agent, *Mycobacterium paratuberculosis*, is quite similar to the mycobacteria that cause tuberculosis in birds and swine.

CLINICAL SIGNS

Frequently, infected animals are culled for other reasons, such as breeding problems or mastitis, before the typical signs of Johne's disease become apparent. Although the onset of clinical signs depends somewhat on the number of bacterial organisms ingested, the first signs of illness most frequently occur in cattle at three to five years of age. The animals become thin, develop a rough, off-colored coat or lose hair, and have periods of moderate to severe diarrhea. They may have intermittent fever and frequently refuse to eat or drink. Runny eyes, increased breathing sounds, and signs of intestinal distress may be noticed. Eventually affected animals become depressed and develop muscle tetany that forces them to hold their heads to one side. Death may occur after prolonged, intermittent bouts of diarrhea and weight loss.

DISEASE PROGRESSION

In most cases, the bacteria are ingested during nursing; then they slowly multiply within cells in the intestinal wall and in the abdominal lymph nodes. The organisms are shed in the feces for many months before signs of illness appear. They are protected from antibodies formed by the animal and from most drugs that may be used for treatment. The disease develops over a long time period. In a pregnant animal, the disease remains stable during the last two-thirds of pregnancy. Then, within several weeks after calving, the illness may advance very rapidly.

DIAGNOSIS

Most of the serum and allergy tests devised for other diseases have been tried in the diagnosis of paratuberculosis. During the very early stage of infection, few tests are successful. In the tuberculoid stage, skin tests become positive. Some animals that reach this stage eliminate the organisms from their body and recover. Other animals progress to the intermediate stage where tests that detect serum antibody become positive. Beyond this stage, skin tests again become negative. At the time the less sensitive serum tests are positive, the animals usually start shedding enough organisms in their feces to permit detection by fecal cultural techniques. Animals that have recovered or have been exposed to other closely related organisms may react to the serum or skin tests, but only heavily infected animals that are unlikely to recover will be detected by fecal culture. Although animals that are culture positive may not show signs of clinical illness for several years,

they will shed the organisms and expose other animals to the infection. Thus fecal culture is the best test for identifying animals to be culled.

VACCINATION

Both live and heat-killed strains of *M. paratuberculosis* have been used for vaccination. The organisms are inoculated subcutaneously in the brisket area. Live organisms are used for vaccination in Europe, but only the heat-killed bacterin has been approved for use in the United States. The bacterin produces a distinct swelling at the vaccination site, which occasionally will open and drain. The delayed skin hypersensitivity and circulating antibody induced by the bacterin prevent the subsequent use of these testing procedures for detecting infected animals in vaccinated herds. In field trials where herds were vaccinated with the heat-killed bacterin, the number of clinical cases was reduced 90 percent and the number of infected cattle was reduced 50 percent. The use of the bacterin is recommended only when it is not feasible to control the disease by improved husbandry.

CONTROL

Preventing the initial infection is the most desirable option. Although no current test can detect all infected animals, the risk of purchasing an apparently healthy paratuberculous animal can be reduced by testing all animals in the herds from which replacement or breeding animals are to be purchased. Fecal culture, serum tests, or allergy skin tests may be employed. If any animal in the herd reacts, no animals should be purchased from the herd. Obviously, animals should not be purchased from herds in which clinical Johne's disease has been detected.

Once it is established that paratuberculosis is present in a herd, procedures for eliminating the disease must be followed. These include the following husbandry recommendations:

1. Remove newborn animals from their dams at birth and raise them in separate, noncontaminated quarters.
2. Feed the young animals colostrum from cows in a herd free from Johne's disease. Then feed only pasteurized milk or milk replacer.
3. Make sure that no fecal contamination from the adult herd is carried on footwear, feed supplies, and in other ways to the young animals.
4. Do not mix the replacement animals with the adult herd until they are at least one year old.
5. Take fecal samples from all breeding animals for culture at six-month intervals. All animals found to be shedding the organisms should be sent to slaughter as well as all animals that exhibit clinical signs of the disease.
6. Thoroughly clean all equipment, pens, and feed bunks that need to be disinfected to remove all traces of feces. Then saturate with disinfectant that contains orthophenylphenol and a detergent. Quaternary disinfectants will not kill *M. paratuberculosis*.
7. Contaminated feedlots should be plowed and covered with six inches of fresh, noncontaminated soil.
8. Do not spread manure on pastures or hay fields.
9. Serum or allergy skin tests may be useful in nonvaccinated animals to estimate the exposure level within the herd but should not be used as a basis for culling. Currently available tests identify not only the animals that have been exposed to *M. paratuberculosis*, but also those animals that have been exposed to related bacteria such as *Nocardia* or *Corynebacteria*.

10. Vaccinate only when the above husbandry recommendations are not feasible, and even then follow as many of the recommendations as possible, because when young animals are exposed to large numbers of organisms, the protective effect of the vaccine is overwhelmed. If a vaccination program is to be used, the bacterin should be administered during the animal's first month of life. Because the bacterin can produce a serious lesion if accidentally injected into human tissue, it should be administered only by a state-approved veterinarian trained in its use. Permission to vaccinate a confirmed infected herd must be obtained from the state veterinarian.

CRYPTOSPORIDIOSIS—A NEW COCCIDIA CAUSING DIARRHEA IN DAIRY CALVES?

Cryptosporidia are very small coccidia (parasites) differing from all other coccidia in that they develop within the border of the intestinal epithelial cells of the ileum and not in the cells proper. In this location, they multiply and reduce the absorption of nutrients, thus causing diarrhea.

Cryptosporidia have received little attention until recently, partly because the parasites cannot readily be seen with an ordinary microscope. Within the last five years, there have been several reports in which *Cryptosporidia* were associated with diarrhea or death in calves, pigs, and humans. Death occurred in humans with depressed immune systems and was attributed to the presence of the organism along with profuse, continuous diarrhea.

Recently, outbreaks have been reported in some dairy herds where as many as 50 percent of neonatal calves were affected. In some cases, concurrent infections with other known intestinal bacteria have been found, while in others, only *Cryptosporidia* have been isolated. The implications of mixed infections (bacterial and protozoal) are unknown at this time. Studies are continuing on the effect of this organism on cattle and on the public health problem that it creates among humans. It seems likely that the parasite is present asymptomatically in most herds.

Experimental infections have been induced in neonatal calves by inoculating the calves with fecal material known to contain the organisms. Calves begin to develop varying degrees of diarrhea four to five days after inoculation. The stool is often yellow but may later become gray in color. Unless the infection becomes extreme or the animals are immunodepressed, the infection is self-limiting and animals recover within five to ten days after the appearance of clinical signs. Severe natural infections (persistent diarrhea, weight loss, and death) have occurred in herds where sanitation is poor, the bedding is wet, and weather stress is severe.

Almost all of the currently effective coccidiostatic drugs have been tried experimentally in an effort to prevent the infections. None has been effective. Studies to determine the extent of the disease and methods of therapeutic and prophylactic treatment are urgently needed. Currently, improving sanitation and housing and reducing stress on young calves are the only practical control procedures.

Coccidiosis caused by *Eimeria bovis* and *E. zurnei* is prevalent in dairy herds where sanitation is inadequate. This is primarily a disease of calves from two weeks to one year of age, but older animals may be infected or show clinical illness. Animals over 6 to 8 months develop partial immunity if they have been exposed at an earlier age.

The onset of coccidiosis is often quite sudden. The microscopic parasite attacks and ruptures the individual cells that make up the lining of the intestinal tract. The first signs are usually diarrhea or loose stools with or without specks or clots of blood. The animal may strain and not have a bowel movement. The hair coat may become rough and manure will cling to the tail. In advanced cases, dehydration, anemia, and generalized weakness are present. Some forms may cause convulsions.

Calves may carry a low-grade infection without problems unless they are stressed. Weather changes (rain, cold, dampness) or change in housing will often cause subclinical coccidiosis to surface and become clinical.

Diagnosis is made by a laboratory test of stool samples. An occasional calf may exhibit all the signs of disease and yet not appear positive on the lab test. This happens when the infection has not yet developed to the stage where the parasites (oocysts) are shed in the manure.

Animals become infected from contaminated pens and soils. Calves housed in barns, stables, or hutches, where oocyst contamination is high, may become infected. Young calves on overgrazed pasture may also become severely infected.

The disease, which is not related to that in chickens and other animals, can be treated effectively if treatment is initiated early. Several drugs are available and useful in the treatment of coccidiosis in cattle. At present, the drugs used most frequently are the antibiotic ionophores such as monensin and lasalocid and the chemical compounds amprolium and decoquinate. Each of these compounds, by being used as feed additives, offer preventative advantages in large herds where older calves are affected. Dehydrated calves should be given electrolytes and B vitamins orally. Animals with severe anemia may be given blood transfusions.

The prevention of coccidiosis depends on strict sanitation and the ability to recognize and treat the disease early. Calves should be raised in pens that are periodically cleaned of all manure and bedding. Hutches should be moved to a clean spot after each calf is moved out. When calves are raised in small lots, the lots and feeding areas should be cleaned and left vacant between groups. Feeding troughs and water tanks should be free of manure contamination.

VESICULAR STOMATITIS OR FOOT-AND-MOUTH DISEASE?

Vesicular stomatitis is a contagious viral disease that has occasionally appeared in U.S. livestock. Infected herds are quarantined because the disease resembles foot-and-mouth disease. The most recent outbreak of vesicular stomatitis began in June 1982 in Arizona and has since spread to 610 herds in 14 states. The infection was diagnosed in Missouri in December 1982. Since then, infected herds have been identified in Nebraska (May 1983) and Georgia (July 1983).

Vesicular stomatitis (VS) affects cattle, horses, swine, sheep, goats, many wild animals, and, occasionally, humans. It causes blisterlike lesions to form in the mouth (on the tongue, dental pad, and lips) and in the nostrils, on areas around the hooves, and on the teats. These blisters swell and break, leaving raw tissue that is so painful that infected animals generally refuse to eat or drink, and show signs of lameness. Severe weight loss often follows, and in dairy cattle, milk production usually drops sharply.

The current outbreak has caused serious losses in lactating cows. Young stock are seldom affected. Mouth and teat lesions may be severe enough to drastically restrict eating as well as milking. About 25 percent of the cows in a herd may be clinically affected. Complete recovery time is 30 days for individual animals and 60 days for a herd.

The outward signs of VS are identical to those of foot-and-mouth disease (FMD)—a foreign animal disease that has not occurred in the United States since 1929. The only way to tell the two diseases apart is through laboratory tests. In the past, VS occurred sporadically in the United States only in the summer and early fall. Usually, the disease did not spread, and only a few clinical cases were observed. Moreover, the disease was transitory and generally ran its course in about two weeks. A killed vaccine is now available in case the present outbreak becomes an epidemic.

How the disease spreads from herd to herd is not fully known. Once present in a herd, the disease apparently moves from animal to animal by contact or exposure to saliva or fluid from the ruptured lesions. Isolation can reduce spread, and antibiotics help prevent secondary infections. The virus has been isolated from several types of flying insects on infected farms.

Anyone noticing any signs of a vesicular condition— slobbering, lameness, loss of weight, decreased milk production, and blisters— should report these signs to the veterinarian or

state or federal animal health officials immediately! Early detection is vital to diagnosing whether or not the disease is FMD. It is essential to prevent the nationwide spread of FMD, to eliminate possible invasions of FMD, and most importantly, to protect valued livestock.

Cowpox and bovine herpes mammilitis (BHV) are two viral infections that occur in some Illinois dairy herds each winter. Teat vesicles or blisters are common in these two contagious diseases. Mouth lesions are sometimes seen in suckling calves infected with these viruses, but in adult cattle these lesions occur only occasionally. In both infections, the vesicles may be overlooked and the first teat lesions to be observed may be ulcers or scabs, although teat tenderness may have been noted. The viruses are probably spread by the teat cup, milkers' hands, or common udder sponge or cloth. Some cows develop a fever, decrease their feed intake, and reduce milk production.

Pseudocowpox, a third viral infection, also causes teat lesions (scabs) but seldom produces vesicles or causes fever. This virus is often present simultaneously with cowpox or BHV.

Clearly, it is important to seek professional diagnostic assistance when teat lesions occur abruptly in the herd, especially if new animals have been added. Cows showing teat lesions should be milked last, and iodophor or chlorhexidine teat dips should be used to prevent secondary bacterial invasion of the affected skin.

The chances are not great for vesicular stomatitis to infect an Illinois dairy herd, but the threat should not be ignored.

Reduced Dosage Brucella Vaccine

PAUL SPENCER AND R. DAVID McQUEEN

The reduced dosage vaccine of *Brucella abortus*, Strain 19, is now commercially available. USDA veterinary biologic licenses have been issued to Burroughs Wellcome Company and Colorado Serum Company for sale of the product. In addition, the Bayvet Division of Miles Laboratory is reported to have its product in the final testing stage.

Commercially produced vaccine has become available for use in 16 states where it was not available previously, including Illinois, Indiana, Iowa, Kansas, Michigan, Minnesota, Ohio, and Wisconsin. The reduced dosage vaccine contains from 3 to 10 billion viable organisms in a 2 milliliter dose, whereas the standard vaccine contains 90 billion viable organisms in a 5 milliliter dose. Until now, reduced dosage vaccine was available only in states that had special laboratory facilities for diluting the standard vaccine. Now, licensed Illinois veterinarians may buy the vaccine directly from commercial companies of their choice.

The reduced dosage Strain 19 vaccine has been shown to offer substantial protection against brucellosis infection but with less risk that post-vaccination titers will remain and interfere with future blood tests than when the standard 5 cc dose of Strain 19 vaccine is used.

In Illinois, both beef and dairy heifer calves can be legally vaccinated against brucellosis when they are not less than 60 and not more than 210 days old. The optimum age for vaccination with the reduced dosage vaccine, according to currently available information, is from 4 to 7 months. If the full strength Strain 19 vaccine is used, the optimum age remains 2 to 4 months. The preferred product, however, is the reduced dosage vaccine.

Officially vaccinated calves are allowed free movement within Illinois until they are 24 months of age. Even after this age they are given some special consideration in the brucellosis blood test interpretation when vaccination history is provided.

COMMENT

The number of calves vaccinated has increased from 3.4 million in 1975 to 7.6 million in 1982. That rate should increase even more now that reduced dosage vaccine is available in Illinois and other midwestern states. More states now require or strongly recommend vaccinating calves. At least 20 states now have some requirements regarding the vaccination of imported cattle. Thus in addition to increasing the immunity of dairy cattle to brucellosis on exposure, vaccination increases the market value of vaccinates.

As of October 1, 1983, there were 11 Illinois herds that were quarantined because of brucellosis infection, including one dairy herd. Infected herds were present in counties scattered throughout Illinois. To reduce the risk of introducing brucellosis into your herd buy only officially vaccinated heifers. Adult cattle should be blood-tested and found negative before they are purchased. They should also be isolated for 30 to 120 days and retested before they are added to your herd. The longer isolation period is for cows tested immediately before purchase.

University of Illinois
Research Reports

Particle Size of Total Mixed Diets

MICHAEL R. MURPHY AND DANIEL G. GIACOMINI

As the feeding of total mixed diets becomes more common, so does concern about the physical form of the ration. If forage material in these diets is chopped too finely, rumen function and milk composition may be adversely affected. A field study was made of the particle size of total mixed diets being fed in herds of four cooperating Illinois dairy producers. Our objective was to establish a reference data base for evaluating the distribution of particle size in diets fed to lactating dairy cattle. Dairy producers submitted samples on their DHI test day of ten diets and ingredients for three months. The particle size distribution was measured by dry-sieving each sample in duplicate. Results of the study are given in Table 1.

Table 1. Summary of DHIA Production Data and Diet Particle Size

Herd	Ration	Number of cows	Day of lactation	Daily milk, lb	Fat %	Ration mean particle size, μm
1	1	35	90	64.1	3.9	3,065
	2	36	187	45.8	3.8	3,235
	3	32	253	30.6	4.5	3,525
	4	4	291	24.7	4.6	3,885
2	1	17	122	50.0	3.7	1,895
	2	20	230	32.8	4.2	2,035
	3	3	302	16.5	4.6	2,015
3	1	31	115	60.0	3.5	2,165
	2	32	272	34.8	4.1	2,225
4	1	164	146	45.5	4.1	2,820

The fact that tests showed normal milk fat suggests that mean particle size of diets in this study was sufficiently large. Such data continue to be gathered and will form a valuable reference point for evaluating questionable diets in the future.

Mean particle size (μm) is a useful index, closely correlated with particle length; however, it is not equal to the theoretical length of cut and should not be used to set chop length.

Update on Electronic Grain Feeders

MICHAEL F. HUTJENS AND STEVEN R. SUSLICK

Feeding grain to dairy cows at the correct stage of lactation and in optimal amounts continues to be a challenge to dairy producers using freestall and loose housing facilities. Electronic grain feeders are being introduced on Illinois dairy farms because cows cannot eat the correct amount of grain in the milking parlor; three milk cow groups are not feasible; and complete blended rations cannot be fed. To get more information on these systems, an Illinois field study was conducted in 1983. Thirty-eight producers responded to the survey; 15 had computer feeders, and 6 had a transponder, 2 had door feeders, and 15 magnetic feeders. Costs per cow fed varied from $28 to $438 (Table 1). Milk production response, measured by DHI records, varied. It ranged from a decline of 1,737 pounds per cow the year after installation to an increase of 1,792 pounds. Maintenance costs were low since most units were still under warranty (varying from $18 to $260 annually).

Table 1. Comparison of Various Automatic Grain Feeders

Type	Average installation cost($)	Cost per cow ($)	No. of cows per system	Crude protein (100% D.M.)
Magnetic	903	45	20	17.5
Magnetic	695	28	25	19.2
Door	965	32	30	17.0
Transponder	3,967	131	30	17.1
Computer	25,667	395	65	16.4
Computer	6,750	150	45	12.6
Computer	16,500	257	64	16.0
Computer	13,642	194	70	17.7
Computer	17,500	438	40	19.5

Protein content was calculated for each unit on the basis of the composition of grain mixture sent in by the producer. The average protein level was 17 percent, ranging from 9 percent (ear corn) to 21 percent. Feed ingredients are summarized below:

Ingredient	Number of farms	Ingredient	Number of farms
Shelled corn	29	H.M. shelled corn	2
Soybean meal	19	H.M. ear corn	2
Commercial protein supplement	16	Ear corn.	4
Oats	9	Distillers' grain	1
Molasses	4	Beet pulp	4
Cottonseed meal	1	Bran.	1
		Alfalfa meal.	1

Added fat was supplemented in 4 rations, a low degradable protein source in 9 rations, fiber source in 22 rations, and buffer in 9 rations. The level of added buffer averaged 1.19 percent, ranging from 0.6 (too low) to 2.5 (too high) percent. Only four dairy producers were feeding all grain through the feeder system with amounts that varied from 4 to 21 pounds per cow per day.

The following observations reflect positive reactions to the feeders: a 30 percent savings in grain, improved health and conception, payback in 10 months, higher peak milk and persistency, improved fat test, and no grain feeding in the parlor (calmer cows and less manure). Negative concerns were as follows: more foot problems (magnetic type feeders), lower fat test, excessive grain dispensing rates (over 0.75 pounds per minute), high costs ($1,273 to lease), butting of cows, and heifer adaption (overeating). In addition, these suggestions were volunteered: definitely find a good dealer, guard against lightning strikes, check recalibration regularly, and feed extra grain to certain dry cows and heifers. Our thanks to Illinois producers who volunteered their time and who willingly participated.

Formaldehyde-Treated Soybean Meal for Steers

JIMMY H. CLARK, JERRY W. SPEARS, AND E. EVERETT HATFIELD

Numerous attempts have been made to protect soybean meal from degradation in the rumen by treating it with formaldehyde. Although positive results have been obtained when soybean meal was treated with formaldehyde, results have not been consistent. A major problem encountered in many studies has been decreased protein digestibility, probably resulting from overtreatment of the protein with formaldehyde. The objectives of this study were to determine the influence of the level of formaldehyde treatment of soybean meal on nitrogen utilization and ruminal fermentation by growing steers.

Four rumen-fistulated steers arranged in a 4 by 4 Latin square were fed four experimental diets (dry matter basis) consisting of 42 percent corn silage, 48.5 percent cracked corn-meal mixture and 9.5 percent soybean meal treated with either 0, 0.3, 0.6, or 0.9 percent formaldehyde by weight. Each period in the Latin square was 18 days. Steers were fed twice daily and feed intakes were held constant for each steer at 90 percent of its predetermined intake. Steers were given 10 days to adjust to the diet, and total collections of urine and feces were made the following five days to determine apparent digestibility and nitrogen balance. Rumen fluid samples were collected on day 16 at 0, 1, 2, 3, 4, 6, 8, and 12 hours postfeeding, and ammonia nitrogen concentrations were determined. Polyester bags containing the formaldehyde-treated soybean meal supplements were placed in the rumen on day 17 of each period and removed at 2, 4, 8, 12, and 24 hours to obtain measurements of dry matter and nitrogen disappearance.

Dry matter intake and digestibilities of dry matter, organic matter, and acid detergent fiber were not significantly affected by formaldehyde treatment (Table 1). However, increasing the amount of formaldehyde applied to the soybean meal resulted in a linear decrease in crude protein digestibility (Table 1) and urinary nitrogen excretion (Table 2). When the soybean meal was treated with 0.3 percent formaldehyde, the depression in apparent crude protein digestibility was small (Table 1) and nitrogen retention was greatest (Table 2).

Table 1. Dry Matter Intake and Nutrient Digestibility by Steers Fed Formaldehyde-Treated Soybean Meal

	Formaldehyde, percent			
Parameter	0	0.3	0.6	0.9
Dry matter intake, lb/day	18.0	18.3	18.3	18.3
Apparent digestibility				
Dry matter (%)	71.3	71.9	71.0	70.4
Organic matter (%)	73.4	74.0	73.3	72.6
Acid detergent fiber (%)	51.4	54.0	49.8	52.4
Crude protein (%)	62.6	60.9	55.5	52.3

Table 2. Nitrogen Intake and Utilization by Steers Fed Formaldehyde-Treated Soybean Meal

	Formaldehyde, percent			
Parameter	0	0.3	0.6	0.9
Nitrogen intake, g/day	172	173	175	173
Fecal nitrogen, g/day	64	68	78	82
Absorbed nitrogen, g/day	108	105	97	91
Urinary nitrogen, g/day	87	69	64	63
Retained nitrogen, g/day	21	36	33	28

Ammonia nitrogen concentrations in rumen fluid were lower at all sampling times in steers fed formaldehyde-treated soybean meal (Figure 1). Disappearance of nitrogen (Figure 2) and dry matter (Figure 3) from polyester bags containing the soybean meal supplements and suspended in the rumen was greatly reduced when the soybean meal samples were treated with formaldehyde.

These results suggest that treatment of soybean meal with 0.3 percent formaldehyde will reduce ruminal degradation while having little effect on overall crude protein digestibility, thus resulting in improved nitrogen utilization.

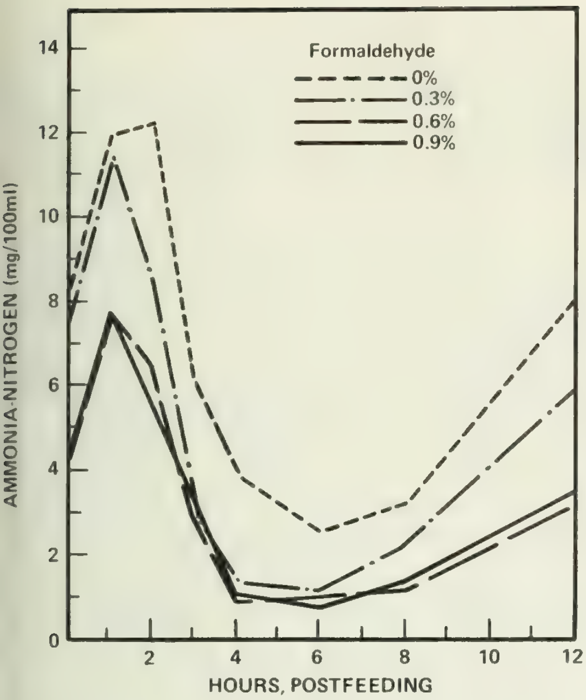


Figure 1. Ruminal ammonia-nitrogen concentrations in steers fed diets containing formaldehyde-treated soybean meal.

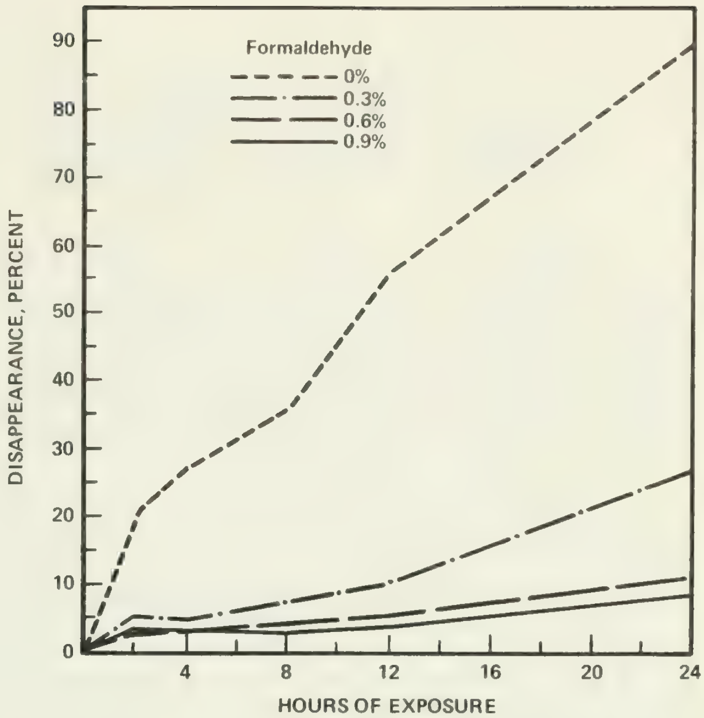


Figure 2. Nitrogen disappearance from soybean meal suspended in polyester bags in the rumen of growing steers.

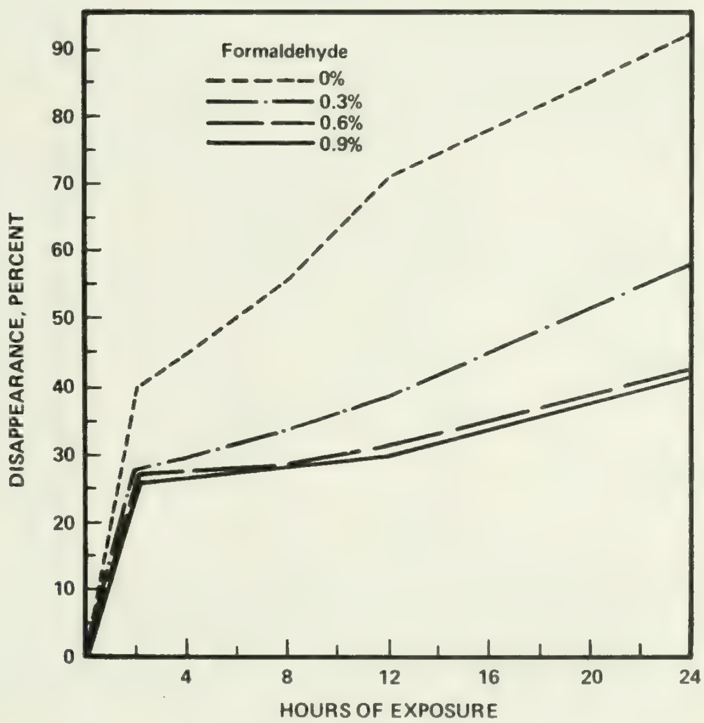


Figure 3. Dry matter disappearance from soybean meal suspended in polyester bags in the rumen of growing steers.

Effect of Postruminal Protein Supplements on Lactation

JIMMY H. CLARK, JOHN A. ROGERS, TOM R. DRENDEL, AND GEORGE C. FAHEY, JR.

Postruminal infusion of sodium caseinate into lactating dairy cows has been shown to increase milk and milk protein production. Sodium caseinate has been the protein chosen in most studies of this type because it is soluble in hot water and is the major milk protein. It thus provides a good pattern of amino acids for the synthesis of milk protein. However, information is limited that demonstrates the effects of postruminal infusion of common feed proteins on milk production and milk composition. This is because of the low solubility of these proteins in water and the difficulty of making a stable suspension for constant infusion.

In this study, four lactating, rumen-fistulated Holstein cows were used in a 4 by 4 Latin square design to determine the effects of postruminally administering different sources of protein on milk production, milk composition, and efficiency of nitrogen utilization. The four treatments consisted of postruminal infusions of one of the following: (1) water, (2) sodium caseinate, (3) soybean meal, or (4) cottonseed meal. Soybean meal and conttonseed meal were micronized to facilitate the suspension of these protein supplements for infusion. Each of the infused proteins supplied 55 grams of nitrogen (344 grams of crude protein) per cow per day. All cows were fed a corn-soybean meal based concentrate at the rate of 1 pound for each 3 pounds of milk produced and alfalfa hay free choice. The cows infused with water were fed an additional 55 grams of supplemental nitrogen (one-half soybean meal and one-half cottonseed meal) with their concentrate and alfalfa hay.

Dry matter intake and dry matter digestibility were similar among treatments (Table 1). Postruminal infusion of protein significantly increased milk and milk protein production. Most of the increase in milk protein production was associated with an increase in casein, with no major change in the nonprotein nitrogen fraction.

Table 1. Dry Matter Intake, Milk Production, and Composition of Milk of Dairy Cows Receiving Postruminal Infusions

	Treatments			
Parameter	Water	Sodium caseinate	Soybean meal	Cottonseed meal
Dry matter intake, lb/day	46.9	45.8	46.3	47.1
Dry matter digestibility, %	62.9	64.2	61.7	60.9
Milk yield, lb/day	67.4	72.0	70.7	68.5
4% FCM yield, lb/day	61.2	63.9	64.5	61.5
Milk fat, g/day	1,038	1,059	1,096	1,035
Milk fat, %	3.40	3.25	3.38	3.30
Milk protein, g/day	1,043	1,146	1,102	1,087
Milk protein, %	3.42	3.51	3.43	3.51

Nitrogen excretion in the feces and urine was decreased when the proteins were infused postruminally, resulting in an improved efficiency of nitrogen use for milk protein synthesis (Table 2). Nitrogen retained in the body was lowest for cows infused with cottonseed meal, but the difference between this value and those for other treatments was not statistically significant.

These data suggest that postruminal infusion of commonly used dietary protein supplements will increase milk and milk protein production. Additional studies will be required to develop methods of protecting these protein supplements from ruminal degradation before they can be fed to improve production of dairy cows.

Table 2. Nitrogen Intake and Utilization by Dairy Cows Receiving Postruminal Infusions

	Treatments			
Parameter	Water	Sodium caseinate	Soybean meal	Cottonseed meal
		grams per day		
Nitrogen intake	611	601	602	609
Nitrogen excreted				
Feces	206	196	205	224
Urine	220	206	202	208
Nitrogen in milk	164	180	173	171
Nitrogen retained	22	20	23	6

The Importance of Water for Lactating Cows

STEVEN T. WOODFORD, MICHAEL R. MURPHY, AND CARL L. DAVIS

Water, which is a vital element of life, is of particular importance to the lactating ow. For their size, high-producing dairy cows require more water than any land-based animal. his is because they have been bred to produce large volumes of milk, which is 87 percent ater. The production of large amounts of milk requires the intake of large amounts of feed ich in energy and protein. The processing (i.e. digesting, absorbing, and metabolizing) of he nutrients in the feed also requires water. Water is an essential carrier of waste from he body via urine and feces. It also helps to reduce body heat by the process of evaporaion. The basic uses of water by the lactating cow are given below.

Priority	General function	Specific function
I	Basic processes of life	a. Maintains body fluids
		b. Eliminates waste materials
		c. Maintains proper ion balance
		d. Aids in heat loss from body
II	Pregnancy	a. Provides a fluid environment for the developing fetus
	Milk production	b. Provides a fluid base for transporting nutrients via the mammary gland.

The highest priority for water is to maintain vital body processes. Milk production an only occur when other functions (survival) have been fully met. Restricting the water ntake of the lactating dairy cow will result in a severe, immediate reduction in milk yield. ecently, a high-producing cow (95 lb milk per day) in the University herd was accidentally eprived of water, and her milk yield dropped to 30 pounds in one day.

Data in Table 1 show water balance in a Holstein cow for a 24-hour period. If water is ot restricted, the animal will regulate its intake to balance output. Note that lactation, lthough low (30 lb per day), caused water intake and output to double. Aside from the loss f water in the milk, all other water losses from the body increased during lactation beause of increased elimination of waste materials.

Table 1. Water Balance in a Dairy Cow[a]

Water intake (gal.)	Dry	Lactating
Drinking water	6.87	13.47
Feed water	0.26	0.53
Metabolic water[b]	0.53	0.79
Total	7.66	14.79
Water output (gal.)		
Feces	3.17	5.02
Urine	1.85	2.90
Vaporized	2.64	3.70
Milk	0.00	3.17[c]
Total	7.66	14.79

[a]Adapted from *Duke's Physiology of Domestic Animals*, 8th edition, 1970.
[b]Metabolic water is that produced within the body.
[c]Note that the cow was only producing slightly over 3 gallons of milk or approximately 30 lb per day.

Several factors influence the water requirements of a cow. Some of the more important ones are dry matter intake, milk yield, water content of diet, mineral salt intake, and environmental temperature.

DRY MATTER INTAKE

Dry matter intake is related to the size of the animal and its production level. Thus the larger the animal and the more milk it produces, the higher will be its intake of dry matter and its water requirement. It has been estimated that if all other factors were held constant, increasing dry matter intake by 10 pounds per day would increase water consumption from 2.0 to 2.5 gallons per day.

MILK YIELD

This factor is so inextricably related to feed intake that it is difficult to measure the effect of milk yield per se on water intake. In those studies where it has been measured, the response comes surprisingly close to the actual yield of water in the milk produced. In one study for example, when all known variables affecting water intake (except milk yield) were held constant, the production of 10 pounds of milk stimulated the intake of 9 pounds of water. This quantity (9 lb) approximates the actual amount of water secreted in the milk (8.7 lb). Thus almost one gallon of water is needed to produce 10 pounds of milk, in addition to the water requirements associated with changes in the other factors.

AMOUNT OF WATER IN THE FEED

This refers to the effect of feed water on the total amount of water consumed. Normally, feed water replaces drinking water up to the point where it depresses dry matter intake. The relationship between the water content of feeds and the amount of drinking water is given in Table 2. Total water intake was essentially the same until water content of the total diet reached about 48 percent, at which point dry matter intake was reduced, resulting in a decrease in total water intake.

Table 2. Effect of Water Content of Feeds on Drinking Water Consumed

	Water in Diet			
Water intake, %	30.7	42.6	48.3	53.6
Drinking water (gal.)	18.1	16.0	14.1	11.4
Feed water (gal.)	3.8	5.6	5.4	4.9
Total water (gal.)	21.9	21.6	19.5[a]	16.3[a]

[a]Lower because of lower dry matter intakes on the high moisture diets.

MINERAL SALT INTAKE

It should not be surprising that water intake is influenced by salt intake. Data in Table 3 show the effect of adding either 2 percent sodium chloride (plain salt) or sodium bicarbonate to a basal ration for lactating cows. Note that dry matter intake was essentially the same for all diets and did not contribute to the increased water consumption.

Table 3. Effect of Additional Salt in the Diet on Water Intake

	Diets		
Intake	Basal	Basal + 2% sodium chloride	Basal + 2% sodium bicarbonate
Dry matter (lb per day)	47.7	47.3	46.0
Water (gal per day)	22.2	28.1	25.8

Water consumption was increased 27 and 16 percent respectively by the extra sodium chloride and sodium bicarbonate. Sodium intake in the form of either of these salts will increase water intake about one-third gallon per ounce.

ENVIRONMENTAL TEMPERATURE

Aside from affecting feed intake (and, indirectly, water intake), temperature changes also affect water intake. In a study where other factors were held constant, a 10-degree change in environmental temperature between 40 and 85°F resulted in a change in water intake of 1.6 gallons per day in mature lactating Holstein cows. Presumably, greater changes in water consumption would occur both below and above this temperature range; at higher temperatures, evaporative losses would increase greatly to reduce the heat load of the body, whereas at lower temperatures, the opposite would occur.

It is fairly simple to estimate the daily requirements for water by establishing a regression equation that includes the major factors that influence water intake. An equation recently developed at Illinois is as follows:

Water intake (gal.) = 4.22 + (0.19 x lb dry matter intake) + (0.108 x lb milk) + (0.374 x oz sodium) + (0.06 x minimum daily temp. in °F)

Example: A lactating dairy cow consumed 40 lb of dry matter and produced 65 pounds of milk. Her sodium intake was 3 ounces. The average minimum temperature for the week was 50°F. One ounce of salt contains 0.394 oz of sodium. One ounce of sodium bicarbonate provides 0.274 oz of sodium.

WI (gal.) = 4.22 + (0.19 x 40) + (0.108 x 65) + (0.374 x 3) + (0.06 x 50)
= 4.22 + 7.6 + 7.02 + 0.44 + 3.2
= 22.5

The temperature of the water offered to dairy cattle affects the amounts they drink. Cows will drink more in winter if the water is warmed. However, the main advantage to hea ing the water in winter is to prevent it from freezing. Cooling the drinking water when environmental temperatures are high will decrease water consumption and respiratory rate, indicating an enhanced body-cooling effect. There is no evidence to show that either of these practices is economical. Hard water has not been shown to affect the performance of lactating dairy cows compared with soft water.

The simplest recommendation that can be made about drinking water for dairy cattle is that a clean, fresh supply should be available at all times.

DUMPS—A Cause of Dairy Calf Mortality

JAMES L. ROBINSON, GARY W. HARPESTAD, AND ROGER D. SHANKS

DUMPS is an inherited condition that has recently been discovered among dairy cattle by scientists at the University of Illinois. DUMPS stands for Deficiency of U M P Synthase UMP synthase is an enzyme that converts orotic acid to the pyrimidine UMP (uridine-5'-monosphosphate). Since UMP is needed for the formulation of nucleic acids (DNA and RNA), the enzyme is found in all cells of the body and is essential for normal growth and develop ment.

Two forms of DUMPS can be distinguished—partial and full. Animals with partial DUMPS have half the normal level of enzyme. Although such cows have higher levels of orotic acid in their milk and urine, they are not directly harmed by partial DUMPS, but their reproductive fitness is reduced. Animals with full DUMPS would have no UMP synthase. Full DUMPS i a lethal condition, as afflicted calves will die either before or shortly after birth. Thes calves would constitute 25 percent of the offspring from matings between animals with partial DUMPS. Such matings should therefore be avoided.

DUMPS has probably existed for at least 40 years. In the *Diamond Jubilee Edition of Holstein-Friesian History* (1960), a situation is described that could have been caused by DUMPS. The "superb daughter of America's Favorite Brood Cow," says the author, "was no ordinary cow. . . . One of the saddest of all days was when she gave birth to a dead male calf sired by her inbred son." Since this episode occurred in 1942 and DUMPS was first ide tified only two years ago, we do not have direct proof that the calf died from DUMPS. That is the implication, however, because 48 of the 53 animals currently diagnosed with partial DUMPS are descendants of "America's Favorite Brood Cow." However, not all cases of calf mortality can be attributed to DUMPS, especially in cases that involve considerable inbreed ing (as in the above incident). The condition, nevertheless, is now present among U.S. dai cattle and is responsible for the mortality of over 1,000 calves per year nationally, with the associated economic loss to dairy producers.

Artificial Insemination (AI) has been responsible for a sizable portion of the increased milk production per cow over the past thirty years. Unfortunately, AI also carries the potential for the hidden and rapid spread of genetically transmitted DUMPS. The spread is hidden because animals with partial DUMPS are not readily detected. It is rapid because mating a clean herd with affected bulls for two generations would result in 12.5 percent ca mortality. Thus DUMPS is like a time bomb with a fuse of unknown length.

DUMPS has indeed been found among AI bulls. Bull-X was one of the first descendants of "America's Favorite Brood Cow" to be used extensively in AI. Because of inbreeding, Bul X was the equivalent of a great-grandson of "America's Favorite Brood Cow" and a half-sib o the sire of the dead calf. Bull-X is dead and cannot be tested directly for DUMPS. Howeve pedigree analysis and other genetic tests make it virtually certain that he had partial DUMPS. Bull-X had over 5,000 production-tested daughters as well as several sons in AI. Half of his offspring will have partial DUMPS while the other half will be normal.

The prevalence of DUMPS in Illinois has been estimated with the help of DHIA supervisors and cooperating dairy producers in the state. Fifty herds were randomly selected from among 1,148 Holstein herds that were on DHIA test. Of these, 17 herds with adequate pedigree information were chosen. Orotic acid, a normal component of cow's milk, is generally elevated in the milk of cows with partial DUMPS. (DUMPS cows accumulate it because they are deficient in the enzyme that metabolizes it.) The presence of orotic acid in milk was used as a criterion to initially screen the 880 cows studied. All cows with a high milk orotic acid were tested for UMP synthase, a procedure requiring an unclotted blood sample. Over 80 percent of the cows with twice the normal level of orotic acid had partial DUMPS. Fifteen cows or 1.7 percent of all cows had partial DUMPS. This is a minimal estimate of prevalence since DUMPS cows do not always show elevated milk orotic acid, particularly early in lactation. Taking this into account, we can assume that the incidence of DUMPS in Illinois may be as high as 2.2 percent. The potential problem may be much greater for particular herds; in one herd surveyed, 10 percent of the cows had partial DUMPS. To date, the condition has only been observed in Holstein cattle, but then, other breeds of dairy or beef cattle have not been examined systematically.

The inheritance of DUMPS is not sex-specific, as both male and female animals can have the condition. Neither is it sex-linked; that is, the defective gene is not on the X or Y chromosome. It follows normal Mendelian genetics, where partial DUMPS is the heterozygous condition (carrier) and full DUMPS is the homozygous condition (lethal). The pattern of inheritance is illustrated in Figure 1.

In the first generation (I), the effects of mating animals with partial DUMPS to normal animals are illustrated. Partial DUMPS is passed to 50 percent of the offspring, regardless of sex. In generation II, the results of mating two animals with partial DUMPS are shown. A quarter of the offspring will have full DUMPS and will die before or shortly after birth. Half the offspring will have partial DUMPS and one quarter will be normal with respect to this condition. Thus of the 75 percent surviving offspring, all will appear normal but two out of three will have the potential of passing the condition to their progeny.

Our understanding of DUMPS is facilitated by the existence of a comparable disease in humans known as Hereditary Orotic Aciduria. This disease is rare and is transmitted in the same way as DUMPS in cattle. Homozygous deficient infants excrete 1,000 times more orotic acid in their urine than normal. They are also anemic, respond poorly to infections, fail to grow, and are mentally retarded. If not diagnosed and treated early, the disease has some irreversible consequences; and, if untreated, the condition is fatal. The disease can be treated with uridine, which can be converted to UMP by a different enzyme. Evidently this treatment is effective, because one individual has undergone 15 years of continuous therapy. This has fully controlled the clinical symptoms and has permitted normal growth and development. Even if effective, however, similar treatment would be too expensive for cattle, as the cost in a mature animal would amount to $50 per day.

Human infants with Hereditary Orotic Aciduria are born at term of normal weight and subsequently develop the symptoms that precede their death. In the womb apparently, the deficient infant can obtain the pyrimidines it needs from the mother's bloodstream. After birth, when deprived of this supply, the infant can no longer grow and survive.

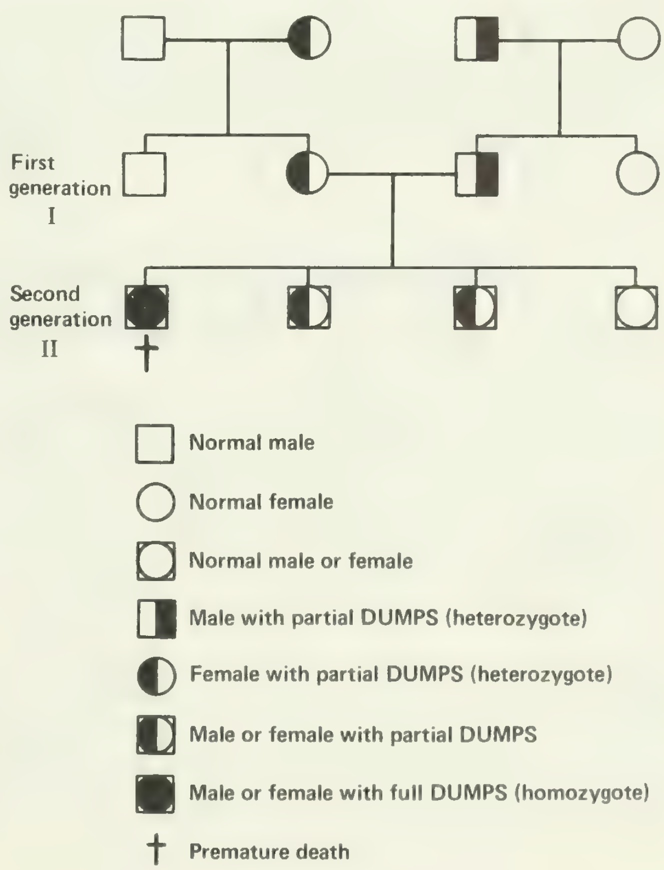


Figure 1. Pattern of inheritance for DUMPS.

With calves, however, we do not know whether DUMPS causes death in utero, at birth, or shortly thereafter.

Humans who are heterozygous for the condition have half the normal level of enzyme, as do cattle with partial DUMPS. In both species, heterozygotes are largely unaffected. In humans, urinary orotic acid is slightly elevated (fivefold). In lactating cows, orotic acid levels are elevated in urine and blood as well as in milk. However, when immature or dry, heterozygous cows have normal values for urinary and blood orotic acid, precluding thei usefulness in detecting the condition. The enzyme UMP synthase reaches mature levels by the time the animal is three months old, and thus DUMPS can be detected early in animals. Presen testing methods are not yet suitable for detecting the enzyme in large numbers of animals. However, either conventional methods or those involving recombinant DNA technology will be developed to screen for the condition.

Research at the University of Illinois is continuing to examine the diagnosis, consequences, and treatment of DUMPS. It is important to establish whether offspring with full DUMPS die in utero or postpartum. This will require planned breedings of heterozygous cows with heterozygous bulls. Careful monitoring of services per conception, abortion, stillbirth, live delivery, and calf survival will be necessary. The genotype will be determined for all live births, and if possible, for any aborted fetus or stillborn calf. It will also be necessary to establish the efficacy and cost-effectiveness of any proposed treatment.

If the condition is not arrested, the increasing incidence of DUMPS could eventually have severe economic consequences. At present, the disease is estimated to account for 0.01 percent mortality of U.S. dairy calves. In a "worst case" scenario, DUMPS could cause over 10 percent calf mortality. After full evaluation, a decision will have to be made as to whether the condition should be eradicated and, if so, how. Perhaps merely identifying AI bulls with DUMPS would be sufficient to prevent the spread of the condition. Until testing can be done and carriers identified, individual dairy producers should minimize inbreeding their animals.

DUMPS is only one cause of calf losses. The research on DUMPS, in addition to providing understanding and control of the disease, will serve as a model for research on other inherited diseases in dairy cattle and other livestock. These diseases are often responsible for mortality and associated infertility. Discovering and controlling disease conditions will enhance the efficiency of American agriculture.

The Feeding Value of Sweet Corn Residue for Dairy Heifers

EDWIN H. JASTER AND GENE C. McCOY

In certain areas of Illinois, significant amounts of sweet corn are grown that result in vast quantities of sweet corn residues, husks, cobs, cull ears, and part kernels. Sweet corn residue usually is ensiled either in stacks close to a processing factory or in bunker silos on individual livestock farms. Since most sweet corn factories are located in Illinois, Wisconsin, and Minnesota, livestock producers in those states could have ready access to an alternative roughage source for dairy heifers. This study was conducted to establish the feeding value of sweet corn residue. Experiments were conducted to measure dairy heifer digestion (Trial 1) and performance (Trial 2).

Three diets were used in Trial 1. Diet 1 consisted of sweet corn residue fed free choice. Diet 2 was a mixture of 50 percent sweet corn residue and 50 percent corn silage (dry matter basis); and Diet 3 contained only corn silage. Feed intake was restricted in the last two diets to ensure that dry matter intake was equivalent to that in the sweet corn residue diet. Trial 1 utilized twelve Holstein heifers for 9 weeks and was designed so that each heifer would receive each diet for a 3-week period. Sweet corn residue was higher in moisture (79 percent), fiber (NDF, ADF, and ADL), and crude protein than corn silage (Table 1).

Data for digestibility of dry matter, cellulose, hemicellulose, and crude protein are given in Table 1. Dry matter and crude protein digestibilities were lower when heifers were fed sweet corn residues (Diet 1) than when they were fed the mixed diet (Diet 2).

Table 1. Chemical Analyses and Digestibility of Rations Containing Sweet Corn Residue

Variable	Roughage source: Sweet corn residue (Diet 1)	Sweet corn residue 50% Corn silage, 50% (Diet 2)	Corn silage (Diet 3)
Composition		*percent*	
Dry matter	21.0	...	49.9
NDF[a]	59.4	...	40.6
ADF[b]	37.4	...	24.8
ADL[c]	5.8	...	4.6
Hemicellulose[d]	22.0	...	15.8
Cellulose[e]	32.5	...	20.9
Crude protein	10.8	...	8.2
Apparent digestibility			
Dry matter	59.1	68.1	69.7
NDF	64.1	66.2	59.8
ADF	56.9	61.1	52.2
ADL	5.4	28.1	32.6
Hemicellulose	75.9	74.8	70.0
Cellulose	66.7	65.5	54.0
Crude protein	46.0	55.9	55.2

[a]Neutral detergent fiber.
[b]Acid detergent fiber.
[c]Acid detergent lignin.
[d]NDF minus ADF.
[e]ADF minus ADL.

The digestibility of hemicellulose and cellulose in Diet 1 was not different to that in Diet 2. Mixing sweet corn residue and corn silage together in equal dry matter ratios at feeding increased dry matter digestibility 13 percent as compared with feeding sweet corn residue alone. Dry matter and crude protein digestibilities in Diet 1 were less than in Diet 3. Sweet corn contained 32 percent more cell wall than did corn silage, which made Diet 1 lower in dry matter digestibility than Diet 3.

Trial 2 evaluated the 70-day performance of dairy heifers on two diets: (1) free choice sweet corn residue and (2) restricted corn silage. In Diet 1, heifers consumed free choice sweet corn residue dry matter at 1.4 percent of body weight. Average daily gains (0.062 versus 1.74 lb per day) were lower for heifers on this diet than those fed a restricted diet of corn silage. The ratio of feed to gain for heifers fed Diet 1 was 21.4 as compared with 7.5 for those on Diet 2. Additionally, measurements indicated that heart girth was greater for heifers consuming corn silage.

From the results of this study, we can conclude that sweet corn residue can be incorporated into the rations of dairy heifers at 40 to 50 percent of the total dry matter with good results.

Table 2. Mean Performance of Dairy Heifers Fed Corn Silage and Sweet Corn Residue

Components	Roughage source: Sweet corn residue	Corn silage
No. of animals	18	18
Days on feed	70	70
Initial wt (lb)	926	910
Final wt (lb)	970	1,031
Daily gain (lb/day)	0.62	1.74
Heart girth (inch/day)	0.004	0.035
Wither height (inch/day)	0.023	0.027

Soybean-Sorghum Silage in a Double Cropping Forage Program

CHARLES M. FISHER AND EDWIN H. JASTER

Recently, the practice of interseeding soybeans and grain sorghum as a forage component in a double cropping forage program has become popular among Illinois dairy producers. In this program, the small grain crop is planted in the early spring and harvested as silage before the interplanting of soybeans and sorghum. This type of double crop forage program offers the potential of producing high quality feed and of more fully utilizing the land and available facilities.

SILAGE IN 60 DAYS

Interplanted soybeans and sorghum complement each other, providing a short-season summer crop that can produce three to four tons of forage dry matter in a 60-day period. Because seeding is often done several weeks after corn is normally planted, producers have a more flexible cropping program. The sorghum provides high yields of dry matter per acre and the soybeans are relatively high in protein. In a Maryland study, average percent dry matter at harvest was 26.7, 26.0, and 30.8 for grass-legume, soybean-sorghum, and corn silages repectively, whereas crude protein levels were 14.3, 11.0, and 8.3. Thus the soybean-sorghum silage was considerably higher in protein content than the corn silage.

FEEDING VALUE

In a 1982 experiment at the University of Illinois, soybean-sorghum and oatlage were fed to dairy heifers and the feeding value evaluated. The chemical analyses, mean nutrient dry matter intake, and apparent digestibility of these silages is given in Table 1.

Table 1. Chemical Analyses, Mean Nutrient Dry Matter Intake, and Digestibility of Forages

Variable	Oatlage	Soybean-sorghum
Composition	*percent*	
Dry matter	30.4	47.8
NDF[a]	62.1	63.5
ADF[b]	44.4	42.3
ADL[c]	6.2	5.6
Hemicellulose[d]	17.7	21.2
Cellulose[e]	38.2	36.7
Crude protein	11.4	10.7
Apparent digestibility		
Dry matter	53.3	54.9
NDF	52.5	59.3
ADF	49.1	50.5
ADL	3.1	9.6
Hemicellulose	65.5	70.9
Cellulose	58.5	57.1
Crude protein	62.1	49.8

[a]Neutral detergent fiber.
[b]Acid detergent fiber.
[c]Acid detergent lignin.
[d]NDF minus ADF.
[e]ADF minus ADL.

The oatlage was lower in dry matter, neutral detergent fiber, and hemicellulose than the soybean-sorghum silage, but higher in acid detergent fiber, cellulose, and crude protein. The heifers consumed similar amounts of oatlage (12.5 pounds) and soybean-sorghum (12.9 pounds) dry matter per day. Dry matter and hemicellulose seemed more digestible in the soybean-sorghum silage, whereas cellulose and crude protein were more digestible in oatlage.

In a concurrent experiment, 32 heifers (600-pound average body weight) were randomly assigned two treatment groups in an 83-day growth trial. Feedstuffs (oatlage and soybean-sorghum silage) were offered free choice. The data given in Table 2 pertain to the heifers' dry matter intake, body weight grain, heart girth, height at withers, body length, and depth of chest.

Table 2. Effect of Oatlage and Soybean-Sorghum Silage on Heifer Dry Matter Intake and Growth

Component	Feed source	
	Oatlage	*Soybean-sorghum*
Dry matter intake (lb/day)	13.8	13.8
Body weight gain (lb/day)	0.66	0.86
Heart girth (inch/day)	0.03	0.04
Height at withers (inch/day)	0.02	0.02
Body length (inch/day)	0.01	0.02
Depth of chest (inch/day)	0.003	0.002

Dry matter intake and growth patterns were similar for both feed sources. The experiments indicated that soybean-sorghum silage are similar in nutrient quality, palatability, and feeding value to oatlage.

ILLINOIS FIELD SURVEY

In 1982, a survey was conducted of 15 Illinois dairy producers who grew and fed soybean-sorghum silage. Their responses are summarized in Table 3.

A forage double cropping system using soybean-sorghum ensilage may be a desirable agronomic and nutritional option to certain dairy producers because firstly, it provides a way to meet emergency forage needs following winter kill of such perennial forages as alfalfa or birdsfoot trefoil; and secondly, it provides the farmer with an alternative to alfalfa and corn silage production. Farmland may sometimes be unsuitable for alfalfa because of acidic soils, poor drainage, or insect and disease problems. Likewise, corn silage production may be unfeasible because of limited moisture, insect problems, or high cost of protein supplements. Dairy producers will find that the double cropping system has a good chance of succeeding, especially when combined with the recently developed and refined "zero-till" techniques.

Table 3. *Forage Production Practices for Soybean-Sorghum Silage*

Production practices	Dairy producers responding, %	Production practices	Dairy producers responding, %
Average planting date:		Height at cutting	
[illegible]		*Feet*	
5/1-5/15	23	2.5-3	14
5/16-5/31	46	3.1-3.5	14
6/1-6/15	8	3.6-4	51
6/15-6/30	15	4.1-5	14
7/1-7/15	8	5.1-6	7
Seeding rate		Sorghum headed out	
Soybeans planted		Just started	62
		Yes	15
[illegible]		No	15
1 3/4	14	Not applicable	8
2	86		
		Soybeans podded out	
Sorghum planted		Just started	36
Pounds		Yes	7
0	14	No	57
10-13	36	Wet silage	
14-15	14		
16-20	36	*Tons*	
From planting to harvest		2.5-5	18
		6-8	46
Days		>10	36
60-65	46	Reasons for producing crop:[a]	
66-70	8		
71-75	23	Need top quality forage	25
76-80	23	Additional forage source	100
		Double crop	58
		Recommended by structure manufacturer	67
		Winter kill of alfalfa	75

[a]Dairy producers were allowed to select more than one response.

Personal Computers for Balancing Dairy Cattle Rations

JAMES B. LEVERICH AND SIDNEY L. SPAHR

Computers have been used for balancing dairy cattle rations for many years. However, since most of the programs written for ration-balancing have been on main frame computers, they have been available only through Extension advisers and feed companies.

The use of personal computers to keep financial records is becoming more common on farms and in feed companies. With the influx of personal computers in these businesses, the opportunity arises for using these computers to balance rations for dairy cattle. One way to justify the cost of a personal computer for a business is to use it for various operation that will save the business money. For example, using a computer to balance rations can increase the efficiency at which feeds are used on a farm. Such a program not only saves money, it can also make money by formulating a ration that will support maximum milk production.

Two types of personal computer-based ration balancing programs have been developed at the University of Illinois this past year. They are the Illini Ration Analyzer and the Illini Ration Balancer.

ILLINI RATION ANALYZER

Dairy producers, Extension advisers, vocational agriculture instructors, veterinarians, feed company personnel, and feed consultants will find the Illini Ration Analyzer useful for evaluating current dairy feeding programs and for suggesting ration changes. The nutrient levels evaluated include crude protein, energy, acid detergent fiber (ADF), calcium, and phosphorus. The first nutrient that limits milk production is identified. A total nutrient profile of the ration is calculated, which can be compared to NRC (National Research Council) guidelines. Similarly, nutrient requirements for selected goal milk production are calculated and compared to nutrient levels in the ration. The program calculates the amount of crude protein, energy, calcium, and phosphorus that the ration supplies and shows the amounts of crude protein, energy, calcium, and phosphorus that are needed for a given goal milk production. A grain mixture or total mixed ration can be determined by several computer runs until a balanced ration for all nutrients and grain mixture are determined. An example output from the Illini Ration Analyzer is given on the next page.

ILLINI RATION BALANCER

Dairy producers will find the Illini Ration Balancer a useful companion to the Illini Dairy Management System. This program is designed to calculate the amount of grain, supplement, and mineral that should be fed to cows and heifers for maintenance and for milk production. The balancer will calculate individual rations for a large group of animals at one time or may be used to balance a ration for an individual animal.

Dairy producers must enter into the computer the feeds that they wish to use in their rations. Forages are entered as the pounds (as fed) of forage that the producer would like to feed the average-weight animal in the group in which rations are being balanced. Grains are entered as the proportion of each grain that the producer would like in the grain mix. The procedure is similar for supplements and minerals. After the feeds are entered, the program balances the rations for each animal, giving the producer an output that shows how much forage the animal should consume and what grain, supplement, mineral, and limestone levels should be fed to the animal to balance her ration.

The animal's rations are balanced according to NRC requirements. Other factors included in the balancer so that rations are more accurately balanced are *lead factors*, which challenge the cows to produce more milk early in lactation, and a *condition factor*, which allows for optimal body condition before the dry period. An *age factor* is also included to provide first and second lactation cows with extra nutrients for additional growth. Users can change the factors so that the balancer is adapted to the conditions in their particular herds.

This program can be used to calculate rations for computerized grain feeders and will be able to interface with these feeding systems. An example output from the Illini Ration Balancer is given on page 37. This program is under development.

ILLINI RATION ANALYZER

JOHN DAIRYMAN
ROUTE 1
URBANA ,IL,61801
PHONE:217-333-2928
COUNTY NO:CHAMPAIGN

DAIRY EXTENSION SERVICE
315 ASL 1207 W. GREGORY DR.
URBANA,IL 61801
PHONE:217-333-2928

CURRENT FEEDING PROGRAM AND NUTRIENT SUMMARY

FEEDNAME	SAMPLE NUMBER	POUNDS AS-FED	POUNDS DRY MATTER	POUNDS CRUDE PROTEIN	POUNDS ACID DET FIBER	MCALS NET ENERGY	GRAM CAL-CIUM	GRAMS PHOS
ALFALFA HAY	1	25.0	22.5	3.6	8.6	13.1	114	26
CORN SILAGE	3	30.0	10.5	0.9	2.5	7.4	15	9
SHELLED CORN	11	15.0	12.9	1.3	0.4	11.9	1	18
DICAL	21	0.2	0.2	0.0	0.0	0.0	20	16
BICARB	23	0.3	0.2	0.0	0.0	0.0	0	0
SALT	24	0.2	0.0	0.0	0.0	0.0	0	0
TOTALS		70.6	46.3	5.8	11.5	32.3	150	68

LEVEL OF MILK PRODUCTION SUPPORTED BY THE CURRENT FEEDING PROGRAM

NUTRIENT	POUNDS OF MILK AT 3.70 % TEST FOR A COW WEIGHING 1400 LB
CRUDE PROTEIN	55.65
NET ENERGY	67.28
CALCIUM	98.08
PHOSPHORUS	49.69

NUTRITIONAL CHARACTERISTICS OF THE CURRENT FEEDING PROGRAM

CHARACTERISTIC	AMOUNT SUPPLIED
POUNDS OF CRUDE PROTEIN	5.81
PERCENT CRUDE PROTEIN (DM)	12.53
M-cals of NET ENERGY	32.27
M-cal NET ENERGY /100 POUNDS (DM)	69.65
GRAMS OF CALCIUM (DM)	150.20
PERCENT CALCIUM (DM)	0.71
GRAMS OF PHOSPHORUS (DM)	68.28
PERCENT PHOSPHORUS (DM)	0.32
POUNDS OF ACID DET FIBER	11.46
PERCENT ACID DET FIBER (DM)	24.73
POUNDS OF DRY MATTER	46.33
POUNDS OF DRY MATTER / CWT-B.W.	3.31
PERCENT DRY MATTER IN RATION	65.57

(i)

NUTRIENT REQUIREMENTS FOR GOAL PRODUCTION

NUTRIENT	AMOUNTS FOR 65 LB OF 3.70% MILK FOR A COW WEIGHING 1400 LB	CURRENT RATION NUTRIENT LEVELS
CRUDE PROTEIN	6.59 POUNDS	5.81 POUNDS
NET ENERGY	31.52 M-cals	32.27 M-cals
CALCIUM	108.44 GRAMS	150.20 GRAMS
PHOSPHORUS	77.58 GRAMS	68.28 GRAMS

FEED QUALITY VALUES USED

FEEDNAME	SAMPLE NUMBER	POUNDS AS-FED	PERCENT DRY MATTER	PERCENT CRUDE PROTEIN	PERCENT ACID DET FIBER	M-cal NET ENERGY POUND	PERCENT CAL-CIUM	PERCENT PHOS
ALFALFA HAY	1	25.0	90.0	16.1	38.0	58.0	1.12	0.25
CORN SILAGE	3	30.0	35.0	8.5	24.0	70.0	0.31	0.19
SHELLED CORN	11	15.0	86.0	10.0	3.0	92.0	0.02	0.31
DICAL	21	0.2	95.0	0.0	0.0	0.0	23.00	18.00
BICARB	23	0.3	95.0	0.0	0.0	0.0	0.00	0.00
SALT	24	0.2	0.0	0.0	0.0	0.0	0.00	0.00

GRAIN MIX/TMR

FEEDNAME	AMOUNT
SHELLED CORN	1917
DICAL	26
BICARB	32
SALT	26
TOTAL	2000

(ii)

ILLINI RATION BALANCER

RATION REPORT

Cow ID	Body Wght (lb)	Milk (lb)	Fat (%)	DMIP[a] (%)	For[b] DM (lb)	DMI[c] EX	Grain (lb)	Supp (lb)	Min (lb)	Lime (lb)
3674	1500	105.0	3.20	3.59	22.5	*	33.7	7.2	0.6	0.0
3995	1400	85.0	4.00	3.50	21.0	*	30.4	6.1	0.4	0.0
4104	1600	97.0	3.20	3.29	24.0	*	30.6	5.5	0.5	0.0
4280	1350	40.0	5.00	2.74	26.2		12.9	0.0	0.2	0.0
4293	1300	60.0	3.50	2.96	19.9		20.6	2.7	0.3	0.0
4299	1200	80.0	4.10	3.52	18.0	*	26.2	5.1	0.4	0.0
4327	1200	65.0	4.10	3.21	18.0	*	21.1	3.0	0.4	0.0
4369	1200	75.0	3.70	3.33	18.0	*	23.3	4.0	0.5	0.0
4450	1050	55.0	4.70	3.34	15.7	*	22.0	4.1	0.2	0.0
4639	1100	55.0	4.50	3.13	16.5	*	18.7	2.5	0.3	0.0
TOTAL		717.0			199.8		239.5	40.2	3.8	0.0

[a]Dry matter intake expressed as a percent of body weight.
[b]Forage dry matter intake expressed as pounds per day.
[c]An asterisk indicates that total dry matter intake (forage and grain) exceeds projected NRC values.

FEEDS IN RATION

Feedname	DM (%)	CP (%)	MCal (100 lb)	Calc (%)	Phos (%)	Feed (lb D.M.)	Prop (%)
Ear corn	86.0	9.0	84.0	0.05	0.26	0.0	100.0
Soybean meal 44	90.0	49.0	90.0	0.36	0.75	0.0	100.0
Dical	95.0	0.0	0.0	23.00	18.00	0.0	100.0
Haylage	57.0	18.0	58.0	1.28	0.20	19.9	79.2
Corn silage	35.0	9.0	68.0	0.22	0.23	5.2	20.7

Personal Computers for On-Farm Cow Records

DEWAYNE E. DILL AND SIDNEY L. SPAHR

The personal computer or microcomputer is causing an unprecedented change in rural life and in methods of farming. Dairy producers have long recognized the need for detailed information and records concerning individual cows. In fact, they were one of the first farm groups to accept the routine use of a computer as a management tool.

Using a microcomputer for dairy management offers many new opportunities. The microcomputer industry has developed a number of highly versatile, general purpose programs that are designed for specific applications by users with little or no computer background. We have selected a commercially available data-base-management-system (dBASE II) for an individual cow record system for on-farm use.

A typical data-base-management-system (DBMS) has built-in functions for data entry, updating and deleting records, sorting, requesting specific data, and writing reports. To program an individual cow record system on a microcomputer without a DBMS would be a monumental task requiring a highly trained programmer. The use of dBASE II as the core for the Illini

Dairy Management System allows our program to operate on most microcomputers. Included in this list are the IBM-Personal Computer, Apple II+ or IIe, and any microcomputer that uses a CP/M (Control for Microcomputers Program) operating system.

The system is designed to be user-friendly—it uses a "menu approach" to prompt the user. It allows the user to enter data or to obtain information by responding to questions. The data base is stored by the DBMS in such a way that the user does not need to know the actual file structure. The DBMS and an application program (in this case for dairy cattle records) combine to process or retrieve data according to the user's request, but without any instructions from the user as to how to accomplish the task. It is analogous to asking a taxi driver to take you home and expecting the driver to know where you live.

Several key features are included in the design of the data base. First, items in the data base are supplemental; they are not intended to replace DHIA records for production and management. A second feature is the inclusion of breed registry and breed improvement programs. The data base also contains specific information judged to be important in the building of equity in the value of animals (type score, cow index, etc.).

Data entry screens are designed to facilitate easy data entry. All screens use a format that conforms to the familiar system used by the dairy producer. For instance, the classification screen is identical to the form filled out by the classifier.

A final feature of the application program is that it provides continuity to the data base. When an animal freshens with a heifer calf, a record of the new animal is automatically inserted into the data base. All her identification information, including birth date and sire and dam registration numbers, are also automatically inserted.

A semen inventory is maintained and updated automatically by entering the service sire for each breeding. Performance information about the service sire is maintained so that genetic summaries of the mating program can be easily made.

One of the features of the system that is particularly attractive is the DBMS query option. This feature allows the user to quickly locate and extract pieces of data and to display or print them. Thus information about a cow, a service sire, or groups of animals with a common feature (pregnancy status, location, sire) is always immediately available.

A number of herd summaries are available. Health and reproductive summaries can be printed in a variety of ways. Lists of cows to freshen, cows to dry off, cows for pregnancy exams, and inventory listings have been found useful in relation to the University herd.

The range of applications is gradually increasing as more hardware becomes available for automatic data entry. For example, automatic data entry is currently being tested at the University's Dairy Research Farm. Grain consumption data and every-milking milk yields are being recorded on the system via automatic electronic transfer of data. This automatic data entry is made by coupling the microcomputer to the controllers for electronic grain feeders and electronic milk flow meters via RS 232 data transmission lines. The microcomputer currently can accept data from DeLaval, Data Feed, and Surge automatic grain dispensers and from Boumatic milk flow meters.

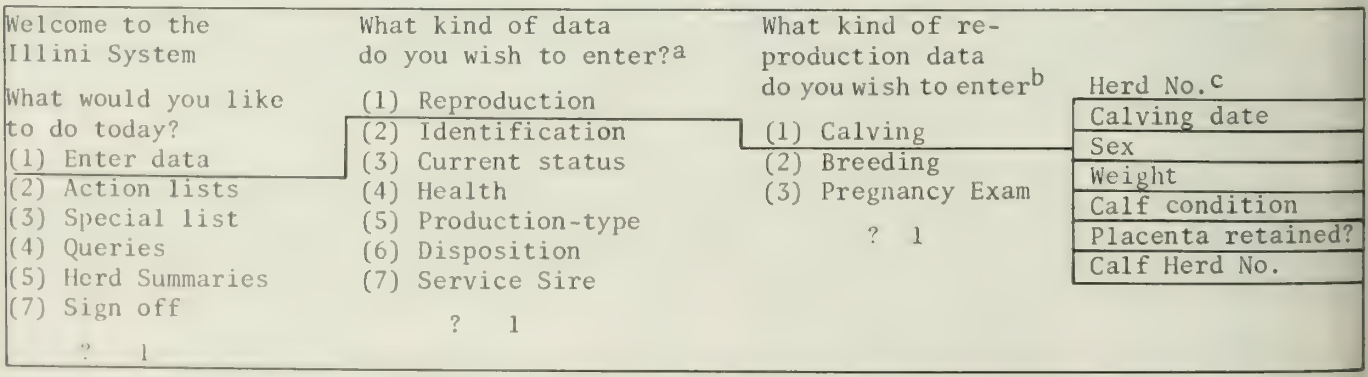


Figure 1. Sample of screens for entering calving data. [a]*Entry 1 from screen 1.* [b]*Entry 1 from screen 2.* [c]*Data entered.*

Welcome to the Illini System

What would you like to do today?

(1) Enter data
(2) Action lists
(3) Special lists
(4) Queries
(5) Herd summaries
(6) Sign off

? 2

What action lists do you wish to create[a]

(1) Cows due to freshen
(2) Cows to dry off
(3) Cows for pregnancy exam
(4) Cows to watch for estrus

? 1

Enter dates for start and end of the cows-due-to-freshen list[b]

Beginning date / /

End date / /

Figure 2. Sample of screens for listing cows due to freshen between two dates. [a]Entry 2 from screen 1. [b]Entry 1 from screen 2.

A System for Automatic Detection of Subclinical Mastitis

RANJIT S. FERNANDO, SIDNEY L. SPAHR, AND HOYLE B. PUCKETT

An automatic system for detecting subclinical mastitis in dairy cows has been developed and is being evaluated at the University's Dairy Automation Center. The system is based on the principle that the electrical conductivity of milk will differ between normal and infected quarters. Most subclinical infections caused by the major mastitis pathogens result in varying degrees of damage to the secretory epithelium of the mammary gland. Milk composition is consequently changed. One of the several changes is an increase in sodium and chloride concentration in the milk. The increase is in turn reflected in an increase in the electrical conductivity of the milk. When the conductivity of milk from a quarter is significantly above normal, or when it is markedly greater than that of other quarters of the same cow, one can assume that the quarter is infected.

The automatic system consists of four conductivity-measuring cells built into the milking claw connected to an electronic control circuit mounted above the stall. The control circuit continuously monitors the conductivity of the milk from each of the quarters as it flows through the cells and transmits the highest reading obtained to the host computer at six-second intervals. At the end of milking, a list of cows with the infected quarter(s) can be obtained.

The system has been highly accurate in identifying the status of infection in the quarters (Table 1). Accuracy in detecting infected quarters was improved from 82.6 percent to 94.7 percent by increasing from one to four the number of milkings from which data were obtained. Since the system is completely automated, it monitors each quarter of each cow at every milking. Unlike other diagnostic tests for mastitis, this system allows one to consider data from four consecutive milkings.

The most obvious advantage of an automatic mastitis detection system over other methods is that the process is continuous, and each quarter of every cow is monitored at least twice daily. The system can thus give early warning of problems associated with udder health. For example, the system can detect acute coliform mastitis in the early stages. This is a disease that can be treated successfully, provided it is

Table 1. Single and Multiple Milkings for Identifying Normal and Infected Quarters with In-Line Conductivity[a]

	Correct detection, %	
Number of milkings	Uninfected quarters	Infected quarters
1	90.7 (2,412)[b]	82.6 (500)
2	92.3 (1,874)	89.4 (433)
3	90.3 (1,786)	94.7 (398)

[a]Infections caused by primary pathogens.
[b]Number of quarters.

detected early. The new system could also detect management problems such as faulty milking machines, poor sanitation, or other conditions that can result in an abrupt change in the udder health of the herd. The system can also be used for screening cows for possible lactation or dry therapy. Although lactation therapy is not at present routinely recommended for subclinical mastitis, early detection and treatment of subclinical conditions using an automatic detection system may result in improved cure rates. Further research on potential practical applications of the system will be undertaken in the future.

Updating the Genetic Bases of Dairy Cattle

ROGER D. SHANKS

The genetic base change is here! Predicted Differences (PD82) calculated by USDA in January 1984 are relative to the 1982 genetic base. The average PD82 of all sires weighted by the number of their first-lactation heifers calving in 1982 defines the PD82 genetic base at zero. A positive PD82 for a sire indicates that his daughters are expected, on the average, to be superior to the average of first-lactation heifers calving in 1982. A positive PD82 does not guarantee that a particular daughter will be better than average. The meaning of predicted differences has not changed. It continues to be a tool for ranking dairy sires on their ability to transmit genetic merit. The new genetic base merely updates the zero point. This can be illustrated by a mathematical function: PD82 = PD74 + the genetic base change, where PD82 and PD74 represent the current and previous genetic bases, respectively.

Time is the main focus of this paper because it is the only factor of PD that has changed. Therefore each trait of each dairy breed has a different genetic base. Table 1 contains genetic base changes for milk and fat yield and fat percentage by breed.

Example 1. Bull A, an Ayrshire, had a PD74 milk proof of +1,237. To estimate his PD82 milk proof, add the genetic base change of -637 to his PD74 milk proof. The new proof for Bull A is +600. Although the PD milk for Bull A is reduced, he ranks the same relative to other Ayrshire bulls because the PD milk of all bulls has declined.

This example could be applied to each of the other breeds; PD milk of all bulls within a breed declined by the same amount from genetic base PD74 to PD82. The change in the genetic base does not change bull rankings. However, more daughters and more information per daughter may change bull rankings between two sire summaries, just as it has in the past.

Genetic base changes in Table 1 indicate that all six dairy breeds have made genetic progress so that milk yield has increased. For Holsteins, genetic progress for milk yield is occurring at a rate of 90 pounds per year. Fat yield has also increased in spite of a decline in fat percentage for most breeds. Milking Shorthorns were the only breed to increase their fat percentage.

One often unmentioned reason that the genetic base was changed was to stimulate additional genetic progress and thereby reduce the opportunity of the dairy industry to rest on its laurels. Producers should be challenged by the progress that has been made: over 95 percent of the active AI bulls were positive for PD milk following the summer 1983 sire summary. In contrast, however, fat percentage has declined, especially in the Jersey breed.

Example 2. A Jersey bull had a PD74 fat percentage of -0.11, which was below the average for 1974. When the genetic base change of +0.16 was added to his proof, the PD82 fat percentage was estimated at +0.05, which was above average for PD82. This improvement may give some dairy producers a false sense of security. But do not be fooled by the genetic base change. This bull, although above average for fat percentage, will not rapidly solve the problems of a low-testing herd.

Cow indexes (CI82) will also change because of the new genetic base. Most genetic progress results from selection of sires, and that progress is transferred to the cow population, where it is manifested several years later. The new genetic base corresponds to an average sire having zero PD82 and the average cow being below zero (Table 2). Both bulls

and cows are expressed to the same genetic base so that they are directly comparable for calculating genetic indexes. Only 20 percent of Holstein cows are expected to have a CI82 for dollars above zero; the averaged CI82 dollars anticipated will be -43 for Holsteins. CI82 milk and fat are also listed in Table 2 for each breed. You have an elite herd if your herd average CI82 for dollars is above zero.

In considering the new genetic base change, dairy producers should not forget what has already been accomplished. They must strive to maintain their breeds' unique contributions to the dairy industry. Dairy producers must evaluate and select superior progenitors for future generations. Use the highest ranking bulls of each breed for sire selection. Do not be complacent about a positive PD or +1,000 PD or +2,000 PD. Each year, selection goals will need to be increased just to stay even with genetic progress. The new genetic base, PD82, merely updates the zero point; it does not change bull rankings. Predicted differences and cow indexes are tools to rank dairy bulls and cows on their ability to transmit genetic merit.

Table 1. Genetic Base Changes[a] for Milk and Fat Yield and Fat Percentage by Breed[b]

Breed	Milk, lb	Fat, lb	Fat, %
Ayrshire	-637	-22	+0.03
Guernsey	-781	-30	+0.07
Holstein	-978	-28	+0.05
Jersey	-993	-34	+0.16
Brown Swiss	-1,094	-35	+0.07
Milking Shorthorn	-992	-41	-0.04

[a]PD82 = PD74 + genetic base change.
[b]Based on information supplied by F.N. Dickinson, AIPL, Agricultural Research Service, USDA, Beltsville, Maryland.

Table 2. Projected Average CI82s for Cows Alive in the January 1984 Evaluations by Breed[a]

Breed	Percentage with positive CI dollars	Average CI82 Dollars	Average CI82 Milk lb	Average CI82 Fat lb
Ayrshire	29	-21	-167	-6
Guernsey	19	-35	-291	-10
Holstein	20	-43	-388	-11
Jersey	15	-46	-375	-13
Brown Swiss	15	-51	-463	-13
Milking Shorthorn	18	-40	-283	-13

[a]Supplied by F.N. Dickinson, AIPL, Agricultural Research Service, USDA, Beltsville, Maryland.

Variation in Milk Constituents

ROGER D. SHANKS, MARK L. KNIEF, AND W. R. (REG) GOMES

A research study was conducted at the University of Illinois to quantify the sources of variation that may affect DHIA testing procedures. Milk samples obtained from five cows were stored in vials or bags at iced or warm temperatures for zero to eight days and sampled

daily except on Sunday (day 6). All samples were analyzed for fat percentage by Babcock testing procedures and by Dairy Lab Services (DLS) using a Multispec M. In addition, DLS analyzed protein percentage and somatic cell count. Four breeds were represented by the five cows; one each was a Guernsey, Jersey, and Brown Swiss, and two cows were Holsteins.

The distribution of differences between DLS fat percentage and Babcock fat percentage is given in Figure 1. The Babcock fat percentage was higher in 18.5 percent of the samples whereas the DLS fat percentage was higher in 43.1 percent of the samples. However, differences in fat percentage between Babcock and DLS were less than 0.3 on 95 percent of the samples. This difference exceeded 0.6 on only 1.5 percent of all samples. The largest two differences in fat percentage between DLS and Babcock occurred 5 and 8 days after the original sampling. The sample on day 5 was also sour. The average difference of DLS fat percentage minus Babcock fat percentage was 0.02 (when one considers that Babcock fat percentage was only estimated to the nearest tenth, the difference is essentially zero). The difference in fat percentage between DLS and Babcock was not significant. Babcock was not found to be superior to DLS, nor was fat percentage of DLS significantly higher than the fat percentage of Babcock procedure.

Container, temperature, and time were not significant sources of variation in DLS fat percentage. Vials and bags did not influence DLS fat percentage in any systematic way. Technical difficulties resulted in two punctured bags, one sour sample in a cold bag on day 5, and two sour samples in warm bags on day 7. Although warm temperatures, created by heating the milk samples to over 100°F (38°C), simulated the worst summer conditions, DLS measured the fat percentage accurately. Also, DLS estimates of fat percentage did not deteriorate during the week of sampling. Cows, primarily representing breeds, were the major factor influencing fat percentage.

The Babcock fat percentage did not vary significantly with container, temperature, or time. Bags showed a slight trend to average 0.06 higher fat percentage than vials. Warm temperatures tended to average 0.07 higher fat percentage than ice-cold temperatures.

Protein percentages calculated by DLS showed greater variation than the fat percentages for container, temperature, and time. Warm samples averaged 0.14 higher protein percentage than cold samples. Protein percentage had a tendency to increase over time, especially in samples stored in warm temperatures. Icde samples were relatively stable in protein percentage for all cows. Somatic cell count varied significantly by container, temperature, and time. Lower somatic cell counts were associated with bags, cold temperatures, and short storage times. Somatic cell counts averaged 254,000 for cold bags and 448,000 for warm vials. Somatic cell counts increased linearly with longer storage times, especially in warm containers.

In summary, fat percentage calculated by DLS is not significantly different from fat percentage calculated with the Babcock procedure. Fat and protein percentages tended to be higher when samples were not stored on ice but somatic cell counts also increased with the warm samples. These increases for warm samples of fat and protein percentage and somatic cell count were greater at longer storage times. The consistency of samples analyzed by Dairy Lab Services suggests that the Multispec M is a reliable tool for estimating fat and protein percentage and somatic cell count.

Fat percentage[a] DLS-Babcock	Frequency	Percent negative, zero, or positive
-2.3	1	
-1.9	1	
-0.9	1	
-0.6	1	
-0.4	1	
-0.3	3	18.5
-0.2	11	
-0.1	40	
0	122	38.4
0.1	92	
0.2	29	
0.3	12	43.1
0.4	2	
0.5	1	
0.6	1	

[a]DLS fat percentage was rounded to the nearest tenth to be compatible with units of measure for Babcock. As an example, the first entry of -2.3 represents a DLS fat percentage of 3.06 (rounded to 3.1) minus a Babcock fat percentage of 5.4.

Figure 1. Distribution of differences between Dairy Lab Services fat percentage and Babcock fat percentage.

Because cows were the primary factor influencing differences in fat percentages, management decisions about which cows to cull or which cows' milk should be fed to the calves are relatively unaffected by DHIA testing procedures. However, the Babcock fat percentage did have a smaller variance than the DLS fat percentage.

[*A portion of this research study was supported by DHIA of Illinois.*]

Factors Influencing the Fertilization Process

CHARLES N. GRAVES AND MARK S. SIEGEL

Spermatozoa play a critical role in the reproductive process. Their function is twofold: first, to activate the ovum and thus initiate development of the embryo, and second, to transport the male genome into the ovum. Before it can perform either of these functions a spermatozoon must: (1) become capacitated; (2) undergo the acrosome reaction; (3) bind to the outer layer of the ovum, the zona pellucida; and (4) penetrate through the zona pellucida and attach to the ovum membrane. We have undertaken a study of the various factors involved in capacitation and the acrosome reaction of the sperm. The results have helped us to gain an insight into one possible cause of infertility. The results are also directly applicable to our in vitro fertilization experiments.

Although there are no apparent morphological changes in spermatozoa as they undergo capacitation, biochemical changes are evident. These biochemical changes increase respiration and alter the motility pattern of the spermatozoa. The first observable morphological change is associated with the acrosome reaction—the partial disappearance of the acrosomal ridge, an elevation on the anterior portion of the acrosome or head-cap of the spermatozoon. The acrosome then gradually loses its shape, and finally the plasma membrane and the outer acrosomal membrane are completely removed. The contents of the acrosome, consisting almost completely of various enzymes, are then slowly released, helping the sperm bind to and then penetrate the zona pellucida of the ovum.

In these experiments we divided into four categories the morphological stages in the sperm that are associated with disintegration of the acrosome. These were: (1) an intact acrosome, firmly anchored to the sperm; (2) a partial breakdown with a thin space visible between the sperm head and the acrosome; (3) a partially removed or swollen acrosome; and (4) a sperm head denuded of the acrosomal cap. We also checked by interference microscopy the ability of the sperm to bind to and penetrate bovine ova.

Flushings from the uterus and oviduct of cows, removed after slaughter, served as the control medium. Part of these flushings were dialyzed against various buffers in order to remove different components. Another aliquot of these flushings was dialyzed after various components had been added back in purified form. Bovine spermatozoa were initially preincubated in these fluids for either 0, 15, 30, or 60 minutes and then incubated with bovine ova for either 30, 60, 120, or 240 minutes.

The results of these experiments show that there are indeed some critical components in both oviduct and uterine fluids responsible for initiating the changes in the spermatozoa that result in the acrosome reaction and ultimately in sperm penetration of the ovum. After the spermatozoa were preincubated for 60 minutes and incubated for 240 minutes both in uterine and oviduct fluids, almost 30 percent of them had an acrosome reaction (lost their entire acrosomal cap) so that an average of seven sperm bound to and four sperm penetrated each ovum. Preincubation and incubation of the spermatozoa in fluid dialyzed against culture medium containing bicarbonate, calcium, phosphate, magnesium, and sodium ions as well as albumen and glucose resulted in percentages of acrosome-reacted, bound, and penetrating spermatozoa similar to those observed in the control undialyzed flushings. However, preincubation and incubation of the spermatozoa in tris buffer (with albumen and glucose added) resulted in all values being significantly lower than when the spermatozoa were incubated in the undialyzed or bicarbonate systems. The failure of the tris buffer to support the morphological changes in the spermatozoa necessary for penetration into the ovum indicates that these changes are induced by some components present in the other two media and are not

primarily due to the incubation process itself. In both the undialyzed and bicarbonate buffered systems the numbers of sperm penetrating each ovum reached a maximum at one hour, while those binding to each ovum continued to increase for the full four-hour period. In the tris buffer both penetration and binding were much lower but increased somewhat during the four-hour period.

Of the other factors thought to influence capacitation and the acrosome reactions, the steroid hormones estrogen, testosterone, and progesterone did not seem to play a part. Other experiments in this study, however, did indicate that the level of bovine serum albumen in the medium is critical: between 4 and 20 mg BSA per ml of media stimulated the acrosome reaction, sperm-binding to ova, and also sperm penetration. Albumen has previously been shown to be a major component of reproductive tract fluids. Subsequent experiments have also shown calcium to contribute both to capacitation and the acrosome reaction.

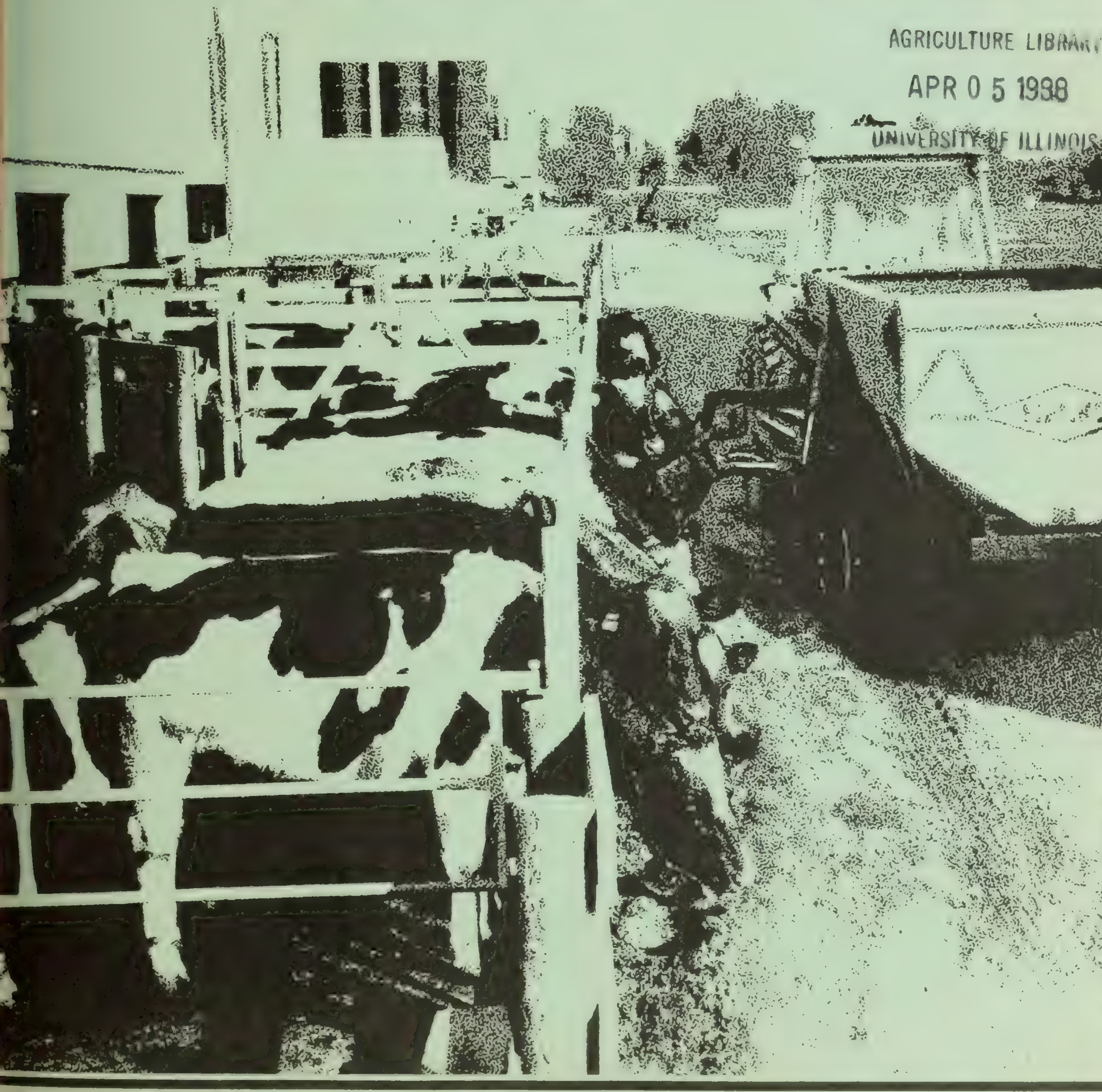
Our experiments have shown that certain components present in the oviduct and uterine fluids play a necessary part in conditioning the spermatozoa for their role in the fertilization process. Both calcium ions and albumen have been implicated. Low levels of either of these in the reproductive tract fluids may be one cause of fertilization failure in our livestock.

1985

1985
Illinois Dairy Report

Department of Dairy Science
Cooperative Extension Service
Agricultural Experiment Station
College of Agriculture
University of Illinois at Urbana-Champaign

Managing During "Normal" Times



1985 Illinois Dairy Days

January	14	Kankakee, Redwood Inn
	15	Marengo, Cloven Hoof Restaurant
	16	Freeport, Masonic Temple
	16	Elizabeth, Community Building
	17	Sterling, Emerald Hill Country Club
January	18	Pekin, Agricultural Center
	22	Quincy, Farm Bureau Building
	23	St. Libory, American Legion Hall
	24	Breese, American Legion Hall
	25	Teutopolis, Knights of Columbus Hall

Authors

Department of Dairy Science, University of Illinois at Urbana-Champaign, except as noted

JIMMY H. CLARK, professor, nutrition

RAYMOND G. CRAGLE, professor, dairy science

BRADLEY A. DIDION, research assistant, physiology

CHARLES M. FISHER, research assistant, management

W.R. (REG) GOMES, professor, reproductive physiology

DON W. GRAFFIS, professor, agronomy

CHARLES N. GRAVES, associate professor, reproductive physiology

MICHAEL F. HUTJENS, professor, Extension dairyman

EDWIN H. JASTER, assistant professor, management

BRUCE L. LARSON, professor, biochemistry

JOEL A. LAWITTS, research assistant, physiology

JAMES B. LEVERICH, research fellow, management

GENE C. McCOY, associate dairy scientist, management

R. DAVID McQUEEN, DVM, professor, College of Veterinary Medicine

MICHAEL R. MURPHY, assistant professor, nutrition

HOYLE B. PUCKETT, professor, agricultural engineering; research leader, USDA-ARS

ERROL D. RODDA, professor, agricultural engineering

ROGER D SHANKS, associate professor, breeding and genetics

STANLEY T. SMITH, area Extension adviser, dairy

SIDNEY L. SPAHR, professor, dairy science

JOHN L. VICINI, research assistant, nutrition

SHELDON W. WILLIAMS, professor emeritus, agricultural economics

Contents

1985 THEME: MANAGING DURING "NORMAL" TIMES

UNIVERSITY OF ILLINOIS RESEARCH REPORTS

The Department of Dairy Science

W.R. (REG) GOMES

In recent years the cost of producing milk has caused the dairy farmers of the United States to adjust to new times by becoming more efficient in the use of facilities, capital, and other fixed costs. This frequently has involved a consolidation of smaller operations into larger ones in order to better take advantage of new facilities and to spread the cost of more expensive time- and labor-saving equipment. Although new management styles have been required to meet the problems existing in larger dairy units, many producers have found this change to be beneficial in returns to labor and investment.

As the costs of conducting teaching, research, and extension programs have increased, we at the University of Illinois have also searched for new ways to become more efficient in the use of the facilities and tax dollars available to us. We are optimistic that the state of Illinois will soon approve funds for a major addition to the Animal Sciences Laboratory on the Urbana-Champaign campus. In order to take full advantage of this facility, to reduce administrative costs in the College of Agriculture, and to efficiently utilize new and expensive pieces of equipment, it was decided that the Department of Dairy Science and the Department of Animal Science would be merged into a new Department of Animal Sciences. As this 1985 edition of the *Illinois Dairy Report* went to press, plans for the merger were progressing through University channels; the new Department of Animal Sciences should become a reality in the spring of 1985.

Dr. John R. Campbell, Dean of Agriculture, has asked me to assure you that the College of Agriculture and the Department of Animal Sciences will maintain a strong commitment to the dairy industry of Illinois, to the teaching of students who will be the dairy leaders of the future, and to the aggressive research and extension programs needed to assist in building a stronger dairy industry in the state and nation. We seek your advice and support as we make the transition to our new academic organization.

The faculty in dairy science (listed below) and I welcome your comments, suggestions, and questions. We appreciate your interest in the 1985 Dairy Days Program and invite you to visit us in Urbana.

FACULTY in DAIRY SCIENCE

Faculty	Specialization
Marvin P. Bryant, professor	Ruminant microbiology
Jimmy H. Clark, professor	Dairy cattle nutrition
Raymond G. Cragle, professor	Reproductive physiology
Carl L. Davis, professor	Dairy cattle nutrition
Charles N. Graves, associate professor	Reproductive physiology
W. R. (Reg) Gomes, professor	Reproductive physiology
Michael Grossman, associate professor	Dairy breeding and genetics
Gerhard W. Harpestad, associate professor	Extension dairyman
Walter L. Hurley, assistant professor	Lactation endocrinology
Michael F. Hutjens, professor	Extension dairyman
Edwin H. Jaster, assistant professor	Dairy cattle management
Ralph V. Johnson, associate professor	Extension dairyman
Bruce L. Larson, professor	Biochemistry and lactation
J. Robert Lodge, professor	Reproductive physiology
Gene C. McCoy, farm manager	Dairy cattle management
Michael R. Murphy, assistant professor	Dairy cattle nutrition
James L. Robinson, associate professor	Biochemistry
Roger D Shanks, associate professor	Dairy breeding and genetics
Sidney L. Spahr, professor	Dairy cattle management

Replacement Heifer Strategies

MICHAEL F. HUTJENS

Adequate numbers of replacement heifers are one key to a successful dairy business. High calf losses reduce culling, slow genetic progress, and remove a source of extra income (sale of breeding stock). Each heifer represents an investment of $1,253 (Table 1).

Table 1. Replacement Heifer Budget from Birth to 24 Months of Age

Feed costs[1]	$520
Variable costs	
Bedding	44
Medical costs	22
Breeding	25
Power and fuel	19
Supplies	19
Overhead	16
Interest	57
Fixed costs	
Building	150
Equipment	108
Livestock investment	153
Labor charges	120

[1]Feed charges based on 7.6 tons of forage hay equivalent, 21 bushels of corn, 170 pounds of soybean meal, 109 pounds of mineral, and 40 pounds of milk solids.

Add to this investment figure the value of the calf at birth. To protect this investment, sound management can not be overemphasized. If a calf is worth raising, it is worth raising well.

KEEP CALF LOSSES LOW

The annual culling rate on midwest dairy farms is 30 to 35 percent. Table 2 illustrates the number of heifers available for voluntary culling, expansion, or sale.

Table 2. Surplus Heifers (Numbers in Italics) Available in a 100 Cow Herd After Culling

Heifer calves born	Calf losses (percent)	Heifers raised	Culling rate (%) 15	25	35
			-----*number*-----		
45[1]	10	40	*25*	*15*	*5*
45[1]	20	36	*21*	*11*	*1*
45[1]	25	34	*19*	*9*	*1*
55[2]	10	50	*35*	*25*	*15*
55[2]	20	44	*29*	*19*	*9*
55[2]	25	41	*26*	*16*	*6*

[1]Calves saved from cows only (90 calves born per year, half are heifers).
[2]Includes calves from cows and first-calf heifers (total calf crop of 110).

The replacement availability will depend on three critical management factors: calf losses, culling rate, and breeding philosophy toward heifers. A herd with a 35 percent culling rate, 20 percent calf loss, and heifers bred to beef bulls has "no extra" heifers available for herd improvement. Calf losses should be below 2 percent. Genetically superior dairy bulls with calving ease information should be used on replacement heifers. Voluntary culling (for example low milk yield) should represent half of cows removed from the herd in comparison to involuntary culling (for example death, mastitis, sterility, feet and leg problems, or health limitations).

PRENATAL NUTRITION AND CALF SURVIVAL

A shortage of protein during the dry cow feeding period appears to affect the ability of the newborn calf to absorb immunoglobulins from colostrum and reduces the calf's protection. Idaho researchers also suggest protein and energy deficiencies could also alter certain biochemical and physiological processes in the unborn calf. Stressed calves developed lesions along the hock joints with hemorrhegic areas and edema. These lesions were similar to a condition called weak calf syndrome which resulted in 5 to 40 percent calf mortality in the Pacific Northwest.

Adequate selenium is needed in the dry cow program to build levels in the unborn calf. A sound mineral and vitamin program is a must for the unborn calf and the dry cow. Dry cows carrying excessive condition should receive adequate nutrients and avoid additional fat deposition.

COLOSTRUM QUALITY AND MANAGEMENT

True colostrum is obtained only from the first milking. Secretions after the first milking for 4 to 5 days after calving are transitional milk lower in immunoglobulins (Ig). The first feeding of colostrum plus the next 2 feedings during the first 24 hours should equal 12 to 15 percent of the calf's birth weight. Two quarts of colostrum should be fed *by hand immediately* after birth (within 15 minutes). The goal is to have over 60 grams of immunoglobulins absorbed by the calf to provide passive immunity for these reasons:

- At birth the calf lacks immunity against disease.
- First colostrum contains 10 percent Ig which drops to 5 percent Ig in the second milking.
- The ability of the calf to absorb Ig decreases rapidly after birth to near zero at 24 hours of age.
- Antibodies (Ig) in colostrum also protect the intestine from infection.

An English study clearly illustrates the importance of colostrum (Table 3).

Table 3. Results of Colostrum Intake on Calf Health

Colostrum intake	Mortality	Illness	Pneumonia	Chilled
	percent			
Little or none	7.9	42.2	5.2	11.4
Some	3.0	24.2	3.2	9.4
Adequate	1.3	1.3	1.4	6.2

If a calf is allowed to nurse its dam, udder conformation is important. If the teat of the dam was 3 inches above the hock, it took 2.1 hours for first suckling, and 17 percent of the calves did not nurse within 6 hours. When the teat was 3 inches below the hock, calves took 5.3 hours to first suckle, and 45 percent did not suckle within 6 hours of birth. If calvings are not attended, it is impossible to know if a calf has not received colostrum due to weakness, a difficult birth, rejection by the dam, or poor udder conformation.

Colostrum quality depends on the age of the cow. Illinois researchers reported Ig levels in third and fourth lactation cows almost double compared to first lactation cows. Producers have reported lower calf losses when calves from first calf heifers were fed colostrum from

older cows. Minnesota workers found Ig levels were higher in Holsteins compared to Guernseys and Holstein Ig levels dropped more slowly. The appearance of colostrum is an indication of its quality (thick and creamy). A colostrometer (a commercially available meter which measures the specific gravity of colostrum) is another method to measure colostrum quality. Do not feed excessively bloody or mastitic colostrum.

Dairy producers should freeze excessive top quality *true* colostrum from older cows in 2-quart portions. Frozen colostrum can be microwaved to thaw without destroying the Ig, but this is time consuming. Heating to high temperatures will destroy Ig values. Storing excess colostrum as soured colostrum will lower Ig levels and it can be held for long time periods. Soured colostrum is an excellent feed for young calves.

Oklahoma researchers studied the routine of administration of colostrum to newborn calves. The rate of serum Ig increased at the same rate if calves nursed from a nipple bottle or were drenched with an esophageal tube. One concern was if the colostrum milk was deposited in the rumen rather than the abomasum, which could slow Ig absorption. This research illustrated that an esophageal tube is an effective method of feeding colostrum to calves too weak or reluctant to nurse after birth. Care must be taken to insure that the tube is placed in the esophagus (throat), not the trachea (windpipe), and that the rumen wall is not penetrated by forcing the tube too far.

LIQUID DIETS FOR YOUNG CALVES

Several products can be fed to young calves. The ranking of sources from best to acceptable is soured colostrum (diluted 2 parts colostrum to 1 part water), whole milk, and milk replacer. Cost, availability of soured colostrum, and surplus milk will affect your decision. Since milk replacers can vary in quality, check the tag to be sure it contains 22 percent protein (milk sources), 10 to 20 percent fat (higher levels under stress), and less than 1 percent crude fiber (low levels indicate milk sources were used). Use the highest quality milk replacer for the first 2 to 3 weeks. Then shift to a more economical replacer if you want to lower costs. Milk replacer is cheaper compared to marketable milk (1 pound of replacer costs 50 cents which equals 8 pounds of whole milk worth 96 cents). Feed 8 percent of the calf's body weight as liquid per day containing 12 to 15 percent solids or dry matter.

ROLE OF WATER

Opinions vary as to whether young calves need free choice water prior to weaning and if it could cause scours. In a series of studies conducted at a commercial research center, several findings were reported. Water did not increase scours, but calves with scours did consume more water. Monitoring water intake may be an early diagnostic tool. After colostrum feeding was stopped (starting on day 4 after birth), calves would initially consume more water, peaking at day 6 and declining until week 3. Calves offered water free choice consumed 26 pounds of calf starter, gained .68 pound per day, and had 4.5 scour days per calf. Calves with no free choice water consumed 18 pounds of starter, gained .4 pound per day, and had 5.4 scour days per calf. This trial covered 4 weeks with early weaning. Young calves can benefit from free choice water if it is kept fresh and clean. Calves need water in calf hutches or other facilities during hot weather. Be sure adequate fluids are fed to calves.

CALF STARTERS

Calves should be encouraged to consume calf starter at 4 to 6 days of age. High quality palatable ingredients should be used to meet nutrient needs (Table 4). Crude fiber levels can be raised to 9 to 10 percent in a complete starter (no forage fed during 8 weeks). Calves can be weaned when they are consuming 1 to 2 pounds of calf starter per day. Limit starter intake to 4 to 5 pounds per day. Calves do not consume significant levels of hay or forage during the first 8 weeks of age. Haylage can be fed to calves if it can be kept palatable, fresh, and free of mold. Feeding pasture or corn silage to young heifers (less than 4 months) is not recommended.

Table 4. Suggested Nutrient Levels of a Calf Starter (100 Percent D.M. Bases)

Nutrient	Minimum level
Protein (%)	16-18
TDN (%)	75
Fat (%)	2
Crude fiber (%)	5
Calcium (%)	.7
Phosphorus (%)	.5
Vitamin A (unit/lb)	2,500
Vitamin D (unit/lb)	250
Vitamin E (unit/lb)	25

MONITORING HEIFER GROWTH

If heifers are going to be large enough to breed at 13 to 15 months of age, large-breed heifers should gain 1.6 pounds per day and small-breed heifers should gain 1.3 pounds per day. For every day beyond 24 months of age that a heifer is not milking, it costs the dairy farmer $2 to $3 in lost milk and greater feed costs and investment charges. New York DHI records reveal that heifers calving at 24 months of age perform equal to older heifers. (Table 5).

Table 5. Relationship of Freshing Age and Milk Performance

Age at first calving (months)	Registered Holsteins		Nonregistered Holsteins	
	1st lact.	2nd lact. increase	1st lact.	2nd lact. increase
	lb milk			
<21	12,622	+1,011	12,003	+494
24	13,576	+1,276	13,006	+930
27	13,935	+837	13,157	+628
30	13,912	+360	13,190	+379
>32	14,108	+761	13,428	+246

Figures 1, 2, and 3 at the end of this article allow managers to plot both wither height and weight gain to discover weak links in the heifer rearing program. Use a scale or a weight tape to measure weight. A measured background grid allows for fast and accurate height measurements. Plot heifers periodically to evaluate your heifer program.

FEEDING ACCORDING TO STATE OF GROWTH

The nutrient needs of heifers change as they mature. Dry matter intake and nutrient needs shift (Table 6). The table clearly points out that a minimum of 4 groups of heifers are needed for optimal growth and economical rations. Use the maximum amount of forage when possible. Nonprotein nitrogen, such as urea, can be used in diets of older heifers (over 6 months of age). Force feed a minimum level of trace minerals, vitamins, and phosphorus. An electronic grain feeder would allow flexibility in grain levels for small, timid, and close-up heifers. Residue forages (corn stalks or ammonia-treated straw) can be successfully used if balanced for energy, protein, minerals, and vitamins.

Table 6. Suggested Ration Specifications for Growing Heifers[a]

	Age (months)			
	4-6	7-12	13-18	19-22
	Average weight (lb, large-breed heifers)			
	300	550	800	1,100
Estimated dry matter intake, lb/day	7-9	12-16	17-21	22-26
Percent of body weight	2.7-3.0	2.7	2.5	2.0
	Nutrient specifications (% of dry matter)[1]			
Crude protein	15-16	14-15	12[2]	12[2]
Total digestible nutrients (TDN)	68-74	62-78	60-63	58-60
Calcium	.60-.75	.50-.60	.50-.60	.40-.50
Phosphorus	.35-.40	.32-.35	.28-.32	.28-.30
Trace mineral salt	.25	.25	.25	.25
Crude fiber[3]	15	15	18	20
Acid detergent fiber	19	19	22	24
Forage[3]	20-60	30-90	40-100	40-100
Vitamin A (IU/lb DM)	1,000	1,000	1,000	1,000
Vitamin D (IU/lb DM)	140	140	140	140

[1]Trace mineral salt, a high-calcium (15-25 percent) and phosphorus (10-20 percent) mineral mixture, and water should be available free choice at all times.
[2]Twenty to 30 percent of the total crude protein may be provided by nonprotein nitrogen sources for heifers weighing more than 800 pounds.
[3]The percent fiber and lowest level of forage are minimum required for proper rumen function. Higher levels of crude fiber and forage are recommended for more economical rations and to limit TDN levels shown above.
[a]SOURCE: University of Wisconsin.

WHAT'S NEW

Monensin is an antibiotic which alters the rumen digestion of feed. This additive has been cleared to be fed to dairy replacement heifers. The suggested level is 100 to 200 milligrams of monensin per head per day depending on weight and forage quality. For the first 5 days, replacement heifers should receive no more than 100 milligrams of monensin per head per day. Weight gain was increased .14 pound per day or 9.8 percent increase in efficiency. Monensin can be fed from 400 pounds of body weight to calving time. No negative effects on reproduction were observed (average days to first estrus, age to reach puberty, or conception rate). Heifers receiving monensin reached estrus 13 days earlier than control heifers. Milk production, fat test, and milk protein levels in heifers receiving monensin were similar to control heifers through the growing, breeding, and gestation periods. Possible situations for using monensin include when heifers are not growing at an optimal rate (1.6 pounds per day for large-breed and 1.3 pounds per day for small-breed heifers) or feed supplies are limited. Fat heifers should be avoided. Do not exceed recommended feeding directions. It is not legal to feed monensin to milking cows since a milk residue problem and lowered milk fat test can occur. The additive clears the digestive tract 48 to 72 hours after the last feeding.

Acidified milk replacer is a new feeding system that has been successfully used in Europe. Organic acids and preservatives are added to a specially manufactured milk replacer. Calves are allowed unlimited access to the liquid with a common nipple. Because the milk replacer is acidified and fed cold, intake is restricted at each feeding and results in frequent nursings throughout the day. The product remains palatable for 3 days at room temperature. Benefits include a lower stomach pH, improved digestibility, and no overloading of the digestive system. Calves must be checked twice a day for health status, and milk replacer must be changed on a regular schedule. Disadvantages include a greater consumption of milk replacer and high cost per pound of milk replacer. Early research indicates no sucking problems occur and scour problem may be lowered; two concerns with young animals in a group pen facility.

Several feeds low in protein degradability were fed as calf starters to calves from birth to 12 weeks of age. The assumption was that low degradable protein sources would result in more amino acids available for productive functions in young calves. However, Pennsylvania researchers found no growth response to rations using by-product feeds low in rumen protein degradability. Possible reasons for this lack of response could be the low quality of the undegraded protein (amino acid composition) and lack of rumen function (no microbial protein synthesized) at this early age. Increasing the percent protein (from 13 to 18 percent) stimulated calf growth and feed intake.

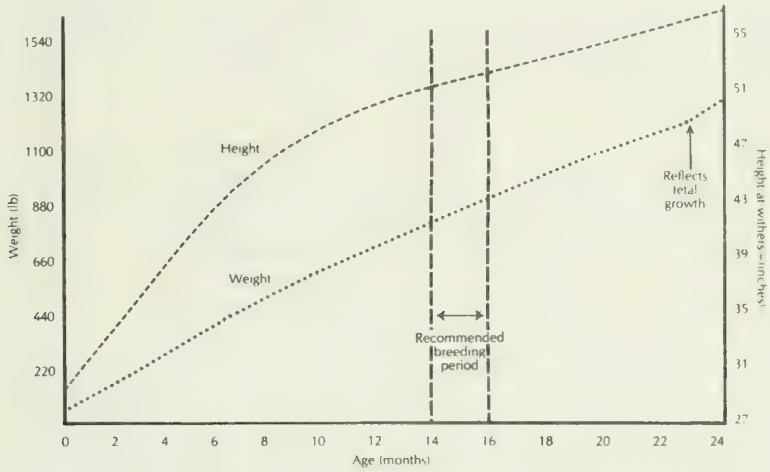


Figure 1. Heifer growth chart for Holsteins and Brown Swiss.

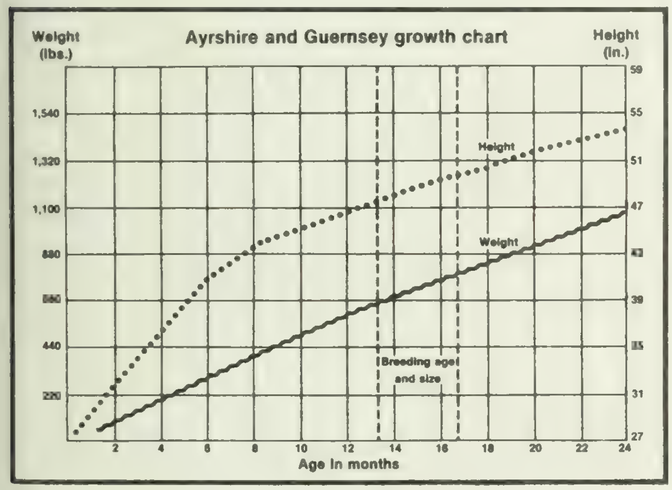


Figure 2. Heifer growth chart for Ayrshires and Guernseys.

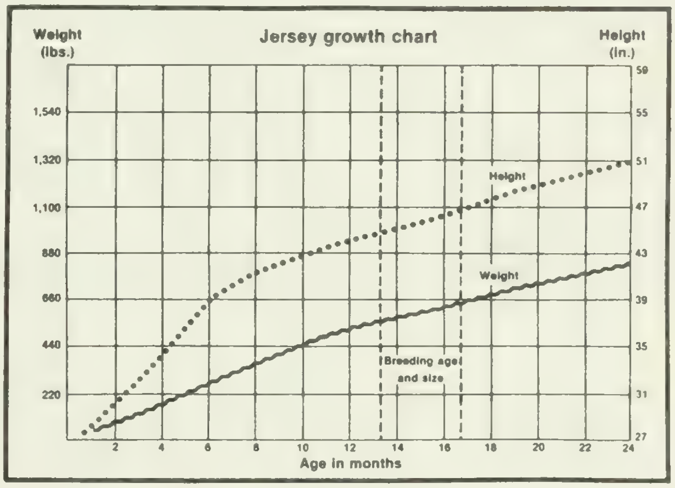


Figure 3. Heifer growth chart for Jerseys.

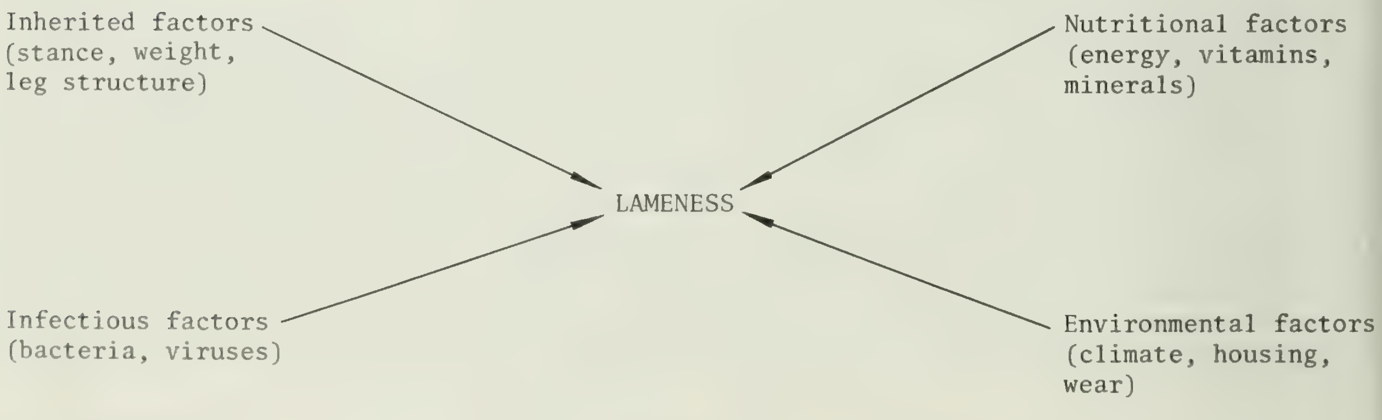
Minimizing Feet and Leg Stress

GENE C. McCOY

Economic pressures have forced many dairy farmers to move dairy cattle from fields and pastures to concrete throughout their productive lifetimes. Confinement housing has many advantages over pasture environment. However, concerns have been expressed about the lameness in dairy cattle under confinement conditions. Lameness is one of the major conditions affecting cattle and has significant economic effects.

It has been reported in Europe that as high as 39 percent of the cattle examined had overgrown or deformed claws. Lameness indirectly reduced milk production (as high as 8 pounds per day) and led to the premature culling of 4 percent of the cases and emergency slaughter of 2 percent, with losses equivalent to $56 per cow per year.

Most summaries indicate that 2 to 3 percent of all cows are culled for foot and leg problems.In a large North Carolina dairy over a period of 10 years (2,266 cows leaving a Jersey herd), 18.5 percent of the cows culled from a confinement housing operation were removed for feet and leg problems. This was second to culling for low production and ahead of mastitis and breeding problems. Illinois researchers have shown in pooled data from university herds that of the total health-related costs of $57 per year, feet and leg problems account for 6 percent of the total. Although financial losses due to lameness have generally been calculated as treatment or replacement costs, losses may occur due to reduced milk production decline in body weight, decreased feed intake, and decreased reproductive performances. A cow with sore feet will be less aggressive at the feed trough, less willing to stand or mount during estrus, and will spend less time on her feet. With cattle lameness recognized as a complex of factors, the diagram below illustrates the four main categories which may lead to lameness.



GENETIC ASPECTS

Heredity is an important predisposing factor in the occurrence of lameness. Abnormalities such as mule foot, crampy, limber leg, and flexed pasterns are undesirable genetic defects of feet and legs. These defects can be eliminated in breeding stock by culling all males and females and close relatives which have produced defective progeny as well as close relatives whether or not they had defective progeny. In commercial herds the culling of carrier sires should restrict the appearance of defects.

Hoof angles, hoof length, heel depth, and ulcers are influenced to at least a moderate degree by genetics. Feet and leg scores are included in type classification of several breed associations with heritabilities for feet being 0.23 and legs being 0.09.

With the low degree of heritability of legs and low occurrence of leg lameness compared to the lameness located in the hoof, one would expect very slow genetic progress. However, leg conformation can cause foot lameness in that cows that are "cow hocked" and more prone to ulcerated soles. Thus, consideration should be made when selecting bulls. With 76 percent of all foot lesions occurring in the hind foot, the outer claw being affected 2 1/2 times more often than the inner claw, and heritability of the hoof traits being moderate (comparable to milk production); moderate genetic progress toward a sound hoof is possible. North Carolina researchers have shown the correlation of desirable hooves (shorter hooves and steeper angles) with high reproductive rates and increased milk yield in later life. Hoof traits of young cows may have a significant effect on their future economic worth.

Although genetic selection will improve the feet of cows in the long run, genetics does not provide a quick answer to hoof problems. However, bulls with high progeny averages for milk also have differences in frequencies of foot problems. Selection of bulls with positive scores for feet from among those bulls with highest PDM should reduce some of the problems now seen in cows which will be milked in 1987 and beyond.

FOOT INFECTIONS

Infections of the hoof originating in the region of the sole of the foot and spreading upward to the toe joint are particularly troublesome and difficult to handle if neglected. Conditions such as foot rot and puncture wounds can be infected by organisms gaining entrance into the inner soft layers of the foot. Other conditions such as sole ulcer, white line disease, and quarter cracks begin as breaks in the hard horn of the foot. If unattended, these problems may develop into more serious infections that affect the joint, tissue, and tendons in the hoof. As this condition worsens, severe damage may occur requiring a long recovery time. If the infection is severe enough, radical procedures such as draining pus are required along with amputation of the toe, which shortens the productive life of the cow. The only other alternative may be to send the cow to slaughter. Some of the most common foot problems leading to the infection of the hoof are listed below.

Foot rot is an acute inflammation of the foot and tissues between the toes that becomes raw and later necrotic with cheeselike discharge and characteristic smell. Approximately 43 percent of cows examined for lameness are affected with foot rot.

White line disease is the separation at the junction of the sole and hoof wall near the heel. Dirt is then impacted in the crevice and forced upward, causing an infection resulting in an abscess. This abscess may break and drain or continue upward and drain at the top of the hoof above the coronary band.

Overgrown feet occurs when the toes of the claw are relatively long and tilt the foot backwards. The animal tends to walk on its heels. Overgrowth rarely causes lameness but may predispose the foot to other conditions such as ulcerations of the sole. The outer claws of the hind feet are usually the most severely affected. The percent of cows affected with overgrowth (26 percent) was second to foot rot in the distribution of lesions and abnormalities among claws.

Sole ulcer is a hole in the sole that develops near the heel close to the inner edge of the hoof. The first visible sign is a red or yellow discoloration of the horny sole, varying in size from a quarter to a half dollar in area. The affected area becomes soft and rubbery and eventually ulcerates. Granulated tissue develops and this sensitive tissue protrudes downward through the ulcer causing lameness on impact. This condition is most commonly found in the outer claw of the hind feet.

Double sole results in two distinct layers of horny sole. Gravel and other debris become trapped between the layers. The inner layer is traumatized, causing the animal to become lame. If left untreated, the hoof may become infected, resulting in a form of chronic foot rot.

Founder or *laminitis* involves the tissues of several hooves and frequently occurs as a complication of other diseases such as mastitis, metritis, and digestive disturbances. It is a potential problem any time large amounts of grain are fed to cattle. Acute laminitis occurs when sensitive tissues which hold the hoof to the foot become inflamed, red, and swollen. The general signs are bunching of the feet, arched back, and reluctance to move. Chronic founder results in changes in the shape of the hoof which becomes long, while the sole becomes wider and flatter.

Soft sole syndrome is similar to sole ulcer and is increasing under current management practices. The horn material of a cow's feet appears to be softer than normal, and this has been associated with large amounts of concentrates and high-energy, finely chopped corn silage, heavy or high-producing cows, wet feet, and rough concrete.

Disease-related foot and leg problems have been reported as a consequence of virus diseases such as BVD, IBR, and PI_3 with visible effects often appearing some months later.

Another possibility is the action of toxic disease conditions in the postpartum period or any other toxic condition which may affect sensitive hoof tissue.

NUTRITIONAL CONCERNS

Little experimental evidence is available to support the view that nutrition plays a part in the incidence of foot disease, but most dairy producers will agree that several nutritional factors can affect lameness and hoof growth in dairy cattle. Diets that contain large amounts of readily fermentable carbohydrates (concentrate feeds) can cause laminitis in dairy cattle (as discussed above). The exact cause for this lameness has not been clearly identified. Diets containing at least 15 percent crude fiber or 19 percent acid detergent fiber will decrease chances of an acidotic condition in the rumen, whereas overfeeding of a high carbohydrate ration creates a lactic acidotic condition. Cows seem to tolerate low levels of laminitis without serious hoof problems if on dirt. But coupled with complete confinement on concrete, many hoof problems will become evident. If high levels of grain are fed, rations should not contain more than 60 percent grain with a maximum of 5 pounds of grain per feeding. The feeding of 1/4 to 1/2 pound of sodium bicarbonate can help control rumen acidosis. Furthermore, protein requirements must be considered along with low degradable protein sources (alfalfa hay, brewers' grain, corn gluten meal) in high producing cows. NPN (such as urea) can affect hoof growth and hardness. Hoof wall is made up of protein that is rich in sulfur amino acids. Research has shown that reduction in sulfur-containing amino acids leads to a variation in the structure of the hoof causing softer foot, which in turn is associated with laminitis. Corn silage and corn grain are typically low in sulfur content in comparison to legumes. Legume forage in the diet will help meet 0.20 percent sulfur requirement in the total dry matter. Other deficiencies in trace minerals such as copper and zinc may trigger certain foot problems. In order to minimize foot problems, the total ration dry matter should contain 15 to 20 ppm of copper and 60 ppm zinc. Zinc methionine, a commercially available product, may improve lameness because zinc is involved in wound healing and combating inflammatory conditions. Suggested levels are 4.5 gm/head/day. EDDI (organic iodine) and chlortetracycline have been used in controlling foot rot. However, due to high levels of iodine in milk and with milk residues, the usefulness of these materials is questionable.

ENVIRONMENT

Foot lesions vary both in type and severity from one farm to another, leading to the conclusion that variations in climate and management systems affect disease incidence. A hot, dry atmosphere dries and hardens the hoof, making it brittle; while warm, moist conditions soften the hoof. Many dairy managers have modern labor-efficient housing for their cattle, only to have a herd of sore footed cows a few months later. A study in North Carolina indicated that cattle in confinement housing with new concrete had hooves that wore off 35 percent more than those on pasture. Although these animals had faster hoof growth rate than those on pasture, the increased growth was not enough to compensate for the greater wear.

The majority of the cow's weight is borne by the hoof wall. The abrasive surface of concrete can wear down the hoof wall to such an extent that the concave shape of the sole is lost. In addition, cows' feet become softer than normal when in contact with water and manure. This, along with factors previously discussed such as feeding large amounts of grain, finely chopped corn silage, high-producing cows, and diseases, allows small objects to penetrate the sole causing lameness (soft sole syndrome). North Carolina researchers noted that growth rate was related to the photoperiod (hours of daylight). The hoof grew fastest during late spring and early summer months and slowest during later fall and winter months. Therefore, hooves probably should be trimmed in late fall after the greatest net hoof growth has occurred. A survey in northern United States indicated that cows housed in free stalls had more major foot problems (43 percent) than those with tie stalls (31 percent) or stanchions (29 percent). In Vermont, herds having tie stalls had deeper heels, claws with steeper angles, and shorter hooves than herds having free stalls.It was also noted that cows housed in tie stalls had dry hooves.

Routine use of footbaths in herds with foot rot has been long recommended. North Carolina workers compared two groups of cows completely confined to concrete for about 1 year. One group had no footbath and the other walked through a copper sulfate bath every milking. Those cows walking through the copper sulfate footbaths showed no severe signs of foot rot. The routinely used footbaths result in shorter hooves and steeper claw angles. Wet or dry footbaths can help harden the hoof and decrease susceptibility to infection. The animals should pass routinely through the baths twice a week. In severe problem herds animals should pass through 5 or 6 times a week. Effective wet baths contain a 2 to 5 percent solution of formaline or a 5 percent copper sulfate solution. One part copper sulfate to 9 parts slaked lime is an acceptable dry bath.

Trimming is a widespread practice but little research on it is available. In a European survey it was shown that trimming the hoof reduced sole lesions specifically in second lactations. After cows with problems are identified, hooves should be trimmed properly. Handling cows during trimming may tend to lower production temporarily. Trimming should occur at least 6 weeks before calving to avoid chances of abortion. Research indicates that hoof trimming may increase milk yield 4 pounds. Cows with lesions experience a loss of approximately 7 pounds per day.

OVERALL RECOMMENDATIONS

1. Breed cows to bulls with positive type scores for feet and legs.

2. Pick hooves up and inspect and trim routinely.

3. Reduce abrasiveness of new concrete.

4. Allow cows off concrete periodically.

5. Adapt heifers to concrete and use of free stalls.

6. Feed diets with at least 19 percent acid detergent fiber in the total dry matter.

7. Use legume forage to meet the 0.20 percent sulfur requirement in the total diet.

8. Control diseases such as BVD, IBR, and PI_3.

9. Use a 2 to 5 percent copper sulfate footbath at least twice a week.

10. Keep feet as dry as possible.

Life After the Dairy Program

STANLEY T. SMITH

The milk diversion program is causing some cutbacks in milk production. Reports indicated that 1984 production is 95-96 percent of that produced in 1983. This reverses a trend of the past few years that saw total production increasing each year.

At the same time there has been an increase in commercial use in recent months. However, it does not appear that these two factors will be large enough to bring about a balance between production and commercial demand.

A big question in the picture is the production of those herds that did not participate in the reduction program. Substantial increases among those herds could cut the effect of the herds in the diversion program.

If production is not cut to levels that will reduce government purchases to amounts specified in the dairy legislation, there will be further reductions in the price support level.

This legislation provides that the Secretary of Agriculture is authorized to reduce support price by 50 cents per hundred on April 1, 1985, if it appears that government purchases for the next 12 months will exceed 6 billion pounds of milk equivalent. Another cut of 50 cents per hundred could be made on July 1, 1985, if it appears at that time that government purchases would exceed 5 billion on an annual basis.

There has been some talk about the 1985 Farm Bill. Several proposals have been put forth, but it is too early to determine which of these will gain the most support.

No one seems in a position to make an accurate estimate of future policy. Most do agree that the short run will not be favorable. The April and July support reductions seem almost certain. Rising costs are putting pressure on profits now. Any reduction in price would severely increase this pressure.

When profit margins decline, each management decision takes on greater significance. Each decision must be based on factual data and take into account the resources available to each individual manager. It means that the proper decision in one set of circumstances may not be a good decision in another. There are fewer general recommendations and more specific ones.

Net income can be increased by increasing gross income, decreasing expenses, or some combination of the two. If the selling price per hundred does not increase, the only means to increase gross income is to sell more pounds of milk. Selling more milk becomes self-defeating if expenses rise at the same rate. It is therefore necessary to keep a firm rein on expenses. It is the relationship of expenses to income that is important—not just the income or the expenses by themselves.

Some areas of expense can be controlled more easily or effectively than others. A good record system is necessary to do an accurate job of decision making. The first step is to analyze what is happening within the dairy farm operation. The second is to determine which items can be controlled most effectively.

Business management studies show that milk sold per cow is one of the major variables affecting dairy farm income. Efficient high-producing cows are a major factor in profitability. Table 1 presents a summary of 6,564 Holstein herds in 9 midwest states. These data show greater income above feed cost for high-producing herds. Herds producing in excess of 18,000 pounds per cow have nearly twice the amount of income to pay labor, other cash costs, and debt service as do herds where the average production is 10,000 to 12,000 pounds per cow. Another way to look at this table is the feed cost in relation to value of

milk. At lower production levels the feed cost is nearly 50 percent of the income from milk. At higher levels feed cost is less than 40 percent of the value of milk sold.

*Table 1. Feed Costs and Returns in 6,564 Holstein Herds for Various Production Levels**

Herd average in lb. milk	Milk value	Feed cost	Income over feed cost
		dollars	
< 9,000	1,114	555	559
10,000 - 11,999	1,391	618	773
12,000 - 13,999	1,625	676	949
14,000 - 15,999	1,862	728	1,134
16,000 - 17,999	2,091	790	1,301
> 18,000	2,340	864	1,476

*DHIA records from Mid-States Processing Center.

Production records are necessary to do an accurate analysis of the dairy enterprise. Averages are sufficient when the profit margin is wide and there is some room for error. When margins narrow, however, an error can be the difference between profit or loss. The greatest value of production records is in showing not just the level of production but rather why the production is at a particular level. Production records are the yardstick by which an astute manager measures changes in practices. Did that new equipment help production? Did those ration changes help or hurt production? Were cuts in expenses detrimental to production? These and many other questions can be answered accurately if records are available.

REVIEW FEEDING PROGRAMS

Feed costs are the largest single expense associated with milk production. The typical Illinois dairy herd is fed a forage-based ration with some 60 to 70 percent of the total ration dry matter being supplied by farm-grown forage. From 25 to 30 percent of the dry matter comes from farm-grown grains and only 5 to 8 percent from commercial supplements.

Great care and consideration is usually given to the purchase of commercial feeds. This is important because these feeds are used to balance the ration to meet the nutrient requirements of the herd. However, the same kind of care and consideration given to the forage production program will likely produce larger dividends. This is simply because forage is a larger portion of the ration. Increasing the quality of the forage supply will improve animal performance by increasing dry matter intake and digestibility.

Forage analysis (usually around $10 per sample) is an excellent investment if properly used in the feeding program. Knowing the correct nutrient content of forages allows proper ration balancing. Small savings in ration costs result in several hundred dollars annually for the average size dairy herd. Many times a balanced ration requires a slight increase in feed cost, but subsequent production responses can be substantial. Increases as small as 1 to 1 1/2 pounds per cow per day will result in $2,500 to $3,000 more profit per year in the average Illinois dairy herd.

Low producers, dry cows, and heifers do not require as great a nutrient intake. Knowing nutrient content and controlling feed supplies can improve the efficiency of feed utilization.

REDUCE MASTITIS PROBLEMS

High somatic cell counts reduce milk quality and milk production. All dairy producers are keenly aware of mastitis costs when milk must be discarded, drugs purchased, or a cow removed from the herd early in her productive life. Yet these costs represent less than one-half of the total problem. Researchers working in this field estimate the true cost of mastitis to be $150 to $175 per cow per year. Well over 60 percent of this cost is due to the decreased milk production associated with a high somatic cell count that indicates subclinical mastitis. Table 2 reflects the reduced milk yield losses associated with elevated somatic cell levels.

Table 2. Lactation Losses in Milk Yield Associated with Increased Linear Cell Count Score

Lactation average linear cell count score	Geometric lactation average somatic cell count (thousand)	Yield loss Lactation 1 (lb/305 days)	Lactation 2	Lactation 2 yield loss* (lb/day)
2	50	0	0	0
3	100	200	400	1.5
4	200	400	800	3.0
5	400	600	1,200	4.5
6	800	800	1,600	6.0
7	1,600	1,000	2,000	7.5

*These losses apply to cows in second and later lactation. Losses in first lactation are one-half these amounts.

This is again a situation in which a regular record program will assist in measuring mastitis control and monitoring changes. Changes in management practices can readily and accurately be evaluated.

EVALUATE REPRODUCTIVE PERFORMANCE

Improving reproduction efficiency will improve the profit potential. Long calving intervals (in excess of 400 days) result in either a long dry period or long lactations in which cows are milking at lower levels.

Heat detection (particularly early in lactation) remains the major problem in breeding efficiency. Time set aside for this purpose is a must if the freshening interval is to be reduced. Research studies have shown that nearly two-thirds of the cows will come into heat between 6:00 p.m. and 6:00 a.m. This means that a good detection program must include observations early and late in the day.

Good reproduction records are needed if heat detection and conception are to be improved. These records should include the important dates in a cow's reproductive cycle. Dates of calving, heat periods, breeding, and examinations are needed to do a good job with reproductive management. Estimating the next anticipated heat period can be helpful in the detection program. Close cooperation with a good veterinarian can be very beneficial. Routine examinations have proven beneficial for many dairy producers.

ASSESS THE BUSINESS STATUS

Some basic financial documents are needed in order to accurately determine the status of a business.

One of these is a statement of assets and liabilities. Commonly called a net worth statement or balance sheet, this states the position of the business at a given point in time. The difference between the value of assets and liabilities is the net worth or equity. Changes in net worth from year to year should be evaluated. Net worth can be affected by change in evaluation of assets. This has been the case for many in recent years. More specifically, increased land value caused net worth to increase for a number of years. Falling land prices recently have caused erosion of net worth.

A second document is the earnings statement, income statement, or profit and loss sheet. It is a reflection of the receipts and expenses for a specified period of time, usually one year. Adjustments should be made for inventory changes. As with the net worth statement, it is beneficial to make some comparisons over a number of years. Any business can tolerate a negative income and expense relationship if the amount is small and/or does not continue for any great length of time. This measure is critical as it measures the profitability of a business.

A third statement that is helpful is a cash flow statement. It shows the cash inflows and outflows by accounting period. This measure is not as important for the dairy enterprise as it is for the total farm enterprise. With milk checks providing a regular income, cash flow binds are not normally as severe on dairy farms as in other types of farming.

Dairy farms that will have the most difficult times in the future are those that have an unfavorable profit and loss statement at present. This means that they are not generating sufficient income to meet expenses. Operators of these farms must take steps to increase income or reduce expenses immediately. In some instances these will need to be rather drastic changes if the businesses are to remain viable.

The partial budget approach can be used to help weigh alternatives. Very simply, the partial budget considers the four possibilities connected with any decision. Any change can:

1) increase income

2) reduce expense

3) add expense

4) reduce income

If the total of 1 and 2 is greater than the total of 3 and 4, the change will be economically beneficial. The limitations of partial budgeting are that it does not always take into account possible effects upon other parts of the operation and it does not select between alternatives. A series of partial budgets can assist in evaluating several alternative actions and may help indicate the most profitable use of resources.

A management strategy that will produce a stable and profitable business in adverse times will fare even better if markets improve. The dairy manager that does well in the future will have to be strong in two areas. One is the knowledge and application of the latest technology to the production of milk. This might also be termed herdsmanship. The second area is that of financial management. Dairy producers are managing more resources today than ever before.

With such factors as the debt load, interest rates, and inflation or deflation, changes occur that have significant impact on the financial security of the business. A decision based on inaccurate or incomplete information can place financial stress upon the business for several years.

University of Illinois
Research Reports

Illinois Hay Quality Program

DON W. GRAFFIS

The Illinois Hay Quality Program is sponsored by the Illinois Department of Agriculture to improve and increase marketing of hay. Increased marketing of hay will be needed if the 900,000 acres of land currently in row crops are removed permanently from row crop production to meet soil erosion standards by the year 2000. Improved hay marketing is an attempt to more equitably market hay from both the seller's and buyer's perspectives. Hay that is sold on a nutrient basis more equitably satisfies the seller and the buyer. Both parties are rewarded for higher hay quality. The livestock industry is also expected to benefit from the Hay Quality Program. As hay and silages are analyzed for nutritional composition, livestock people have an opportunity to more intelligently formulate low cost, high quality, balanced rations. An important analytical tool called NIR is available to improve hay quality.

WHAT IS NIR?

NIR (Near Infrared Reflectance) is a spectrometer which reads light wavelengths, just longer than the visible spectrum, and the intensities of these reflected light rays from a prepared sample. Near-infrared analysis is a nondestructive analytical technique that uses the optical characteristics of a sample to determine major constituent percentages. Results are obtained in a few minutes, including sample preparation time.

HOW DOES NIR WORK?

NIR analysis functions on the physical principle that chemical bonds between elements in a compound vibrate (resonate). Vibrations are an energy expression and reflected light varies with the amount of frequencies of vibrations. A beam of light is directed on the prepared sample. Some of this light is absorbed, some reflected. In many kinds of organic samples, measuring the reflected light is more practical than absorbed light. Absorption spectroscopy requires thin sectioning of the sample. This is practical in some tissue work but not for most agricultural products. The reflected light passes through a high quality prism, dividing the light wavelengths, and then the light is directed to a sensor. The sensor quantifies specific wavelengths of light and directs the information to a computer. The computer is loaded with a series of equations that upon receiving information about particular wavelengths of light and quantity of those wavelengths can calculate what the light is being reflected from and the amount of that constituent. The computer "load of equations" may also be called calibration equations. Put simply, the constituent (hay) is analyzed using scientific methods approved by AOAC (Association of Agricultural Chemists), and readings from the NIR are correlated with the standard results. The earliest reported work on using NIR as an analytical tool was by W. Kaye in 1954. In the early 1970s, R.H. Norris and co-workers at the U.S. Department of Agriculture, Beltsville, Maryland, succeeded in developing a technique that allowed NIR spectroscopic analysis of a variety of natural products of importance to agriculture. These workers employed advanced forms of correlation spectroscopy, diffuse reflectance spectroscopy, and extensive computer processing. The resonating bonds that enabled quantitative measurements by reflectance spectroscopy were primarily of hydrogen. Hydrogen is a nearly universal constituent of organic compounds.

WHAT USE CAN I MAKE OF AN NIR ANALYSIS?

Producers can use NIR to help them grow higher quality hay. The NIR can identify the weak links in the hay production program. Low protein, high fiber indicate advanced maturity or excessive leaf loss. High crude protein, low fiber, high insoluble crude protein indicate that excessive heating may have occurred after baling. Low phosphorus, low potassium, low magnesium, or low calcium may indicate inadequate fertilization and liming practices. Identifying specific nutrients and understanding what can make each of these nutrient values high or low is a basic step toward making plans to improve the hay-making process. See Table 1.

*Table 1. Mineral Composition Levels of First-Cut Alfalfa at the Sufficient Level of Fertilization**

Element	At sufficient level
Nitrogen	2.51-3.70%
Phosphorus	0.26-0.70%
Potassium	2.41-3.80%
Calcium	0.50-3.00%
Magnesium	0.31-1.00%
Sulphur	0.31-0.50%
Zinc	20.0-71.0 ppm
Boron	30.1-80.0 ppm
Manganese	21.0-200 ppm
Iron	30.0-250 ppm
Copper	3.0-30.0 ppm

*Miller, D.A., *Forage Crops*. 1984. McGraw-Hill, Inc., p. 95.

HOW WILL NIR FUNCTION IN ILLINOIS?

An NIR instrument, computer, oven, and drier are housed in a van which will travel around the state upon request to conduct forage crop analysis "on the spot". The Illinois Department of Agriculture Division of Marketing obtained the funding to purchase and operate the NIR unit. The funding and expected revenue are planned to operate the NIR unit for approximately three years. After three years, it is anticipated that farmers in Illinois will be aware of the benefits of forage nutrient analysis for efficient feeding and marketing and that their demands for analysis and services will be met by private laboratories equipped with the rapid analysis technique of NIR.

The Illinois Department of Agriculture (IDOA) Division of Marketing has the responsibility for the NIR program. The Cooperative Extension Service of the University of Illinois, Illinois Forage and Grassland Council, and Illinois Hay Association will be cooperating with the IDOA in activities relating to the NIR program. Requests for scheduling of the NIR van may be directed to the IDOA Division of Marketing, County Cooperative Extension Offices, or other agricultural agencies.

The first three or four months of operation of the NIR van is a *demonstration phase*. The basic objective is to inform farmers of the program and what it can do for them. During this phase, two samples of hay per farmer will be analyzed free of charge. Hay crop silage and corn silage will require a small service charge for extra drying required. The second phase, *service phase*, will operate just as the demonstration phase, but there will be charges for all services. Charges will be determined by the IDOA Division of Marketing staff and are expected to be similar to those of other laboratories performing similar analyses.

Using NIR Forage Test Results in Dairy Rations

MICHAEL F. HUTJENS

Feed value of a forage is determined by its nutrient composition (for example, percent crude protein), intake potential, digestibility, and type of digested products that are used for milk production and/or growth. Since forages make up 45 to 100 percent of dairy cattle rations, accurate estimations of forage quality plus ration formulation result in economical rations and optimal milk yield.

REPRESENTATIVE FORAGE SAMPLING

Samples submitted for forage analysis must be representative of the forages being fed. Poor sampling will result in misleading feed values, higher feed costs, or reduced performance. For correct sampling methods, refer to *Illini Dairy Guide-2*, "Sampling and Testing Forages for Feeding Value," Revised, 1983.

INTERPRETING NIR RESULTS

A sample NIR sheet is illustrated in Figure 1. Each column is discussed below.

				%				
TYPE	SAMPLE	MATERIAL	CUT	CP	DM	CA	K	P
ALFALFA	1	Legume Hay (W)	1ST	13.3	90.7	1.16	2.74	.17
ALFALFA	2	Legume Hay (W)	3RD	19.9	86.6	1.14	3.22	.27

	%							
SAMPLE	ADF	ICP	ACP	ICP/CP	NDF	DDM	DMI	RFV
1	36.3	1.3	12.1	9.5	47.5	60.3	131.1	110.7
2	33.1	1.3	18.6	6.7	54.8	62.9	119.5	105.2

Figure 1. Sample NIR forage analysis report.

CP (crude protein) is a mixture of true protein (amino acids) and nonprotein nitrogen. Protein is essential for milk production and growth. Legume forages are higher than grasses (Table 1).

DM (dry matter) is determined by subtracting the percent moisture from 100. Dry matter level is important since it can limit feed intake, affects fermentation of ensiled feeds, and can indicate if mold or heat damage could have occurred. Feed nutrient values can be expressed on a 100 percent dry matter basis (no water), 90 percent dry matter basis (hay equivalent or air-dry grain basis), or as-is basis (actual dry matter level in the feed). All analytical results on the NIR summary sheet are expressed on a 100 percent dry matter basis.

CA (calcium), K (potassium), and P (phosphorus) refer to the mineral levels in the feed. Since milk is relatively high in these minerals, they can limit milk production. The levels of calcium and phosphorus will reflect the type of forage (grass or legume) and soil fertility program. Table 2 lists the mineral levels needed in the dairy cow ration.

Table 1. Hay Quality Standards

Type	Maturity stage	Composition: CP (%)	ADF (%)	NDF (%)	Relative feed value (%)
Legumes					
Prime	Prebloom	>19	<31	<40	>143
1	Early bloom	17-19	31-35	40-46	126-143
2	Mid-bloom	13-16	36-41	47-51	113-126
3	Full bloom	<13	>41	>51	<113
Grasses					
2	Pre-head	>18	<33	<55	>126
3	Early head	13-18	33-38	55-60	113-126
4	Headed	8-12	39-41	61-65	86-113
5	Post-head	<8	>41	>65	<86

Table 2. Recommended Nutrient Content of Rations for Dairy Cattle

	Lactating cows					
	Body wt.	Milk (lb/day)				
	<900	<18	18-29	29-40	>40	
	1100	<24	24-37	37-51	>51	Dry
Nutrient	1300	<31	31-46	46-64	>64	pregnant
(DM basis)	>1500	<40	40-57	57-78	>78	cows
Energy						
NE_L, Mcal/lb		.64	.69	.73	.78	.61
TDN, %		63	67	71	75	60
Crude protein, %		13	14	15	16	12
Fiber - current recommendation						
CF, %		17	17	17	17	17
ADF, %		21	21	21	21	21
Fiber - proposed guidelines*						
NDF, %		45	39	33	27	49
ADF, %		31	28	24	21	24
Calcium, %		.54	.60	.68	.80	.37
Phosphorus, %		.34	.37	.41	.44	.26

*University of Georgia, D. R. Mertens.

ADF (acid detergent fiber) reflects the amount of bulk (fiber) in the feed. ADF consists of cellulose, lignin, and heat damaged protein. Typical forage values are listed in Table 1. High ADF values indicate low energy content.

ICP (insoluble crude protein) is the amount of protein not available for digestion by the rumen microbes or dairy animal. Heat damaged forage is high in ICP.

ACP (available crude protein) is the amount of crude protein that the dairy animal can utilize. It is calculated by subtracting ICP from CP.

ICP/CP (insoluble crude protein divided by crude protein) is the percent of unavailable protein. In high quality forages, less than 10 percent of CP should be in the ICP fraction. If this percent is over 10 percent, use the ACP value instead of CP value in ration formulation. High ICP/CP values indicate heat damage, mature late cut forage, and/or grass-type forage.

NDF (neutral detergent fiber) consists of cellulose, hemicellulose, lignin, and heat damaged protein. Since NDF is associated with bulkiness of the forage, it is related to feed intake. NDF is the total percent of cell wall. If you subtract NDF from 100, the difference represents the cell content which is highly digestible.

DDM (digestible dry matter) is the digestibility predicted from ADF [DDM = 88.9 - (.779 x ADF%)]. DDM also can be used as an energy value (TDN). TDN or Net Energy-Lactation can also be calculated using these formulas.

Legumes: $TDN\ (\%) = 85.23 - (0.65 \times ADF\%)$

$NE_L\ (Mcal/lb) = 1.044 - (0.0123 \times ADF\%)$

Corn silage: $TDN\ (\%) = 87.84 - (0.7 \times ADF\%)$

$NE_L\ (Mcal/lb) = 1.044 - (0.0131 \times ADF\%)$

Grasses: $TDN\ (\%) = 92.51 - (0.8 \times ADF\%)$

$NE_L\ (Mcal/lb) = 1.085 - (0.015 \times ADF\%)$

DMI (dry matter intake) is the amount of forage or fed dry matter an animal will consume. NDF appears to be highly related to DMI in forages only. The formula to calculate DMI is listed below.

$$DMI\ (g/KgBW^{.75}) = [96.4 - (.0003 \times CP\%) - (.0482 \times NDF\%) - (.0085 \times NDF\%^2)]$$

RFV (relative feed value) is a measure of a forage's feeding value compared to standards of full bloom alfalfa or alfalfa-grass mixtures expressed as a percentage. The formula for calculating RFV is listed below.

$$RFV = (DDM \times DMI)/65.2$$

A high RFV reflects high quality, greater intake, higher digestibility, and improved performance. When buying or selling forage, RFV should be a prime consideration.

USING NIR RESULTS

Dairy producers have an excellent tool to assist them in formulating rations, buying forage, or selling forage. Table 3 shows guidelines for various groups of dairy cattle.

Table 3. NIR Hay and Haylage Guidelines for Dairy Cattle

	Milk cows	Dry cows %	Heifers
Crude protein (CP)	16-24	10-14	10-16
Calcium (CA)	Over 1	Less .6	Over .4
Phosphorus (P)	Over .3	Over .3	Over .3
ADF	Less 35	Over 35	Over 30
DDM	Over 65	Over 55	Over 60
RFV	Over 120	80-100	Over 100

The highest quality forage should be fed to the top milk-producing cows. Low producers can utilize lower quality forage if necessary. Dry cows require less calcium and lower energy to avoid milk fever and fatty liver syndrome. Heifers need above average forage quality for optimal growth or additional grain is needed.

RATION FORMULATION

Producers can hand calculate their rations using tables in *Illinois Extension Circular M-1183*, "Feeding the Dairy Herd." An IBM computer-based "Illinois Dairy Analyzer Program" to summarize your current dairy feeding program for milk cows, dry cows, and heifers is available in some extension offices. The payoff of NIR analysis will be economical and balanced dairy feeding programs.

Transfer of Passive Immunity: Effect of Age and Lactation on Colostrum Immunoglobulin Content

BRUCE L. LARSON

The feeding of colostrum to the newborn calf long has been recognized as essential to the survival and healthy development of the calf. The presence in colostrum of some material that provided protection to the calf against disease and death was one of the earliest known observations of the existence of immune substances. Ruminant animals produce colostrum that contains large amounts of immune proteins, known as immunoglobulins. These consist of antibodies and they are part of the cow's immune defense system, formed in response to previous exposures to foreign proteins, many of which represent disease organisms. At parturition, passive immunity is transferred from mother to young by these antibodies in colostrum.

TRANSFER OF IMMUNOGLOBULINS

A few weeks prior to calving, immunoglobulins from the maternal blood stream begin to accumulate in the mammary gland. The accumulation usually reaches a maximum a few days prior to calving when the contents of the mammary gland are enriched with large amounts of immunoglobulins as well as some other important nutrients for the calf. In contrast to species such as the human and rabbit where antibodies are transferred to the developing fetus via the placenta prior to birth, the newborn calf does not have much immune protection at birth and must receive the antibodies in colostrum for protection. These antibodies, when consumed by the calf shortly after birth, are absorbed across the intestinal wall into its blood stream. This absorptive ability of the calf intestine diminishes rapidly after birth and is essentially gone by 24 hours when "closure" takes place. Sufficient amounts must be present and absorbed to afford a significant degree of protection. The antibodies ingested in colostrum also provide protection against intestinal disease organisms, an important function before as well as after closure.

The transfer of immunoglobulins across the intestine of the calf is not specific and some proteins other than immunoglobulins appear in the calf's blood stream at this time. In contrast, the transfer of immunoglobulins across the mammary gland from the maternal blood to the colostrum is a highly selectvie process and only certain blood proteins appear in the colostrum in significant amount.

CLASSES AND ORIGIN OF IMMUNOGLOBULINS

There are three main classes of immunoglobulins present in bovine colostrum - IgG, IgA, and IgM. These classes differ slightly in structure and function but all represent antibodies to specific foreign proteins that the dam has been exposed to in the past. The IgG class is the most important in bovine colostrum and is composed of two closely related subclasses, IgG1 and IgG2. The source of IgG1 and IgG2 in colostrum is from the maternal blood serum where their concentration is about equal. However, in colostrum, IgG1 is about seven times more concentrated than IgG2. IgG1 constitutes more than two-thirds of total immunoglobulins in typical colostrum.

All immunoglobulins present in the body are produced by a group of cells called plasma cells which are derived originally from bone marrow cells. These plasma cells reside in many different locations in the body and secrete immunoglobulins that collect in the blood

stream. IgA and IgM are also produced by plasma cells but little or none of that in the blood stream goes to colostrum. The IgA and IgM present in colostrum are products of specific plasma cells that lie adjacent to the secretory cells in the mammary gland and transfer their immunoglobulin products directly to the secretory cells. In some other nonruminant species, especially those that transfer IgG to the fetus before birth, the predominant immunoglobulins in colostrum are IgA and IgM, but their relative amounts are much smaller than the concentrations of IgG found in ruminant colostrums.

IMMUNOGLOBULIN CONTENT OF COLOSTRUM

We in the Department of Dairy Science have been interested in this transfer of immunity to the newborn calf. The following summarizes some recent studies (J. E. Devery-Pocius and B. L. Larson, *J. Dairy Science* 66:221, 1983) to determine the effects of age and lactation number on the production of these specific immunoglobulins. This study was based on the observations that some cows, especially first-calf heifers, do not produce sufficient amounts of colostrum for their calves. Conversely, some older cows often produce large extra amounts of colostrum with a high content of immunoglobulins.

Eighty-seven cows were used in this study with about 15 cows in each of 5 lactation groups representing the first, second, third, fourth, and fifth to eighth lactations. The newborn calves were not allowed to suckle and all colostrum was removed and measured. Samples of the first 4 milkings (2 days) were composited into one sample according to volume. Analyses for IgG1, IgG2, IgA, and IgM were conducted on both the blood serum and the composited colostrum samples from each cow. Previous work has shown that over 90 percent of immunoglobulins transferred at parturition are secreted in the first 2 days.

Large differences were found among the animals in this study, both within and between each lactation group. The total amounts of immunoglobulins varied from 255 g produced by a first lactation cow to 2,029 g for a later lactation cow. Previous studies here at Illinois have shown that even higher amounts can be produced (over 6 pounds) by some cows.

The data in Table 1 show for each lactation group the mean age of the cows, the mean IgG1 concentration of the colostrum, and the mean volume of colostrum produced. Statistical standard errors of the means are not shown but the asterisks indicate numbers that are statistically different. It is apparent that the first lactation cows produced significantly less total colostrum and both first and second lactation cows produced colostrum with a lower IgG1 content than those cows in the later lactations. Values for IgG2, IgA, and IgM showed no significant differences.

Table 1. Data on Cows Used in Immunoglobulin Study

Lactation number	Age (mo.)	Colostrum volume (liters)	IgG1 concentration in colostrum (mg/ml)
1	29.9	23.1*	14.5**
2	41.5	36.4	14.3**
3	57.1	35.6	18.4
4	67.0	33.8	21.9
5-8	84.0	32.9	18.6

*Significantly less than older groups.
**Significantly less than oldest three groups.

The mean values for the total amounts of immunoglobulins produced by each lactation group are shown in Figure 1 plotted against the mean age of the cows in each group. Significantly smaller total amounts of IgG1, IgG2, and IgM were produced by the cows in the first lactation group compared to the later lactations. There is a dramatic two-fold increase in the total colostral IgG1, rising from a mean amount of about 300 g in the first lactation to over 600 g in the third and fourth lactations.

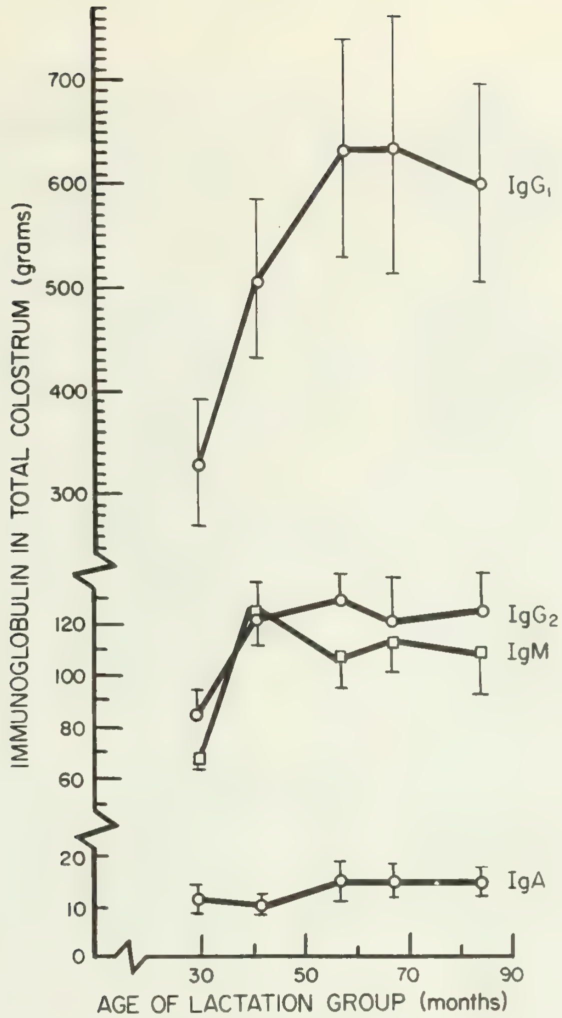


Figure 1. The total amount of immunoglobulins in colostrum as a function of age. The five points for the amount of each immunoglobulin class are plotted at the mean age of the cows in each of the five lactation groups. Vertical lines show the standard errors of the means for each point.

DISCUSSION

These results confirmed the preliminary observations that large differences exist among animals in their production of colostral immunoglobulins and that first lactation cows produce significantly less than older lactation cows. The maximum production of IgG1 in the third and fourth lactation bears a resemblance to that for milk yield versus lactation number, where maximum milk yield usually occurs around the third or fourth lactation. The data suggest that the IgG1 transfer system matures coincident with maximum mammary development.

Several factors are being pursued further that are of research interest and will be the subject of future reports. First are studies to determine the detailed mechanism of the transport process for the immunoglobulins, and IgG1 in particular, through the mammary cells. The second is a study to determine if the IgG1 transport process is a heritable trait. It was observed that cows with very low IgG1 nevertheless had IgG2 amounts comparable to other cows, suggesting that there may be some defect in the IgG1 transport process in the low IgG1 cows. If the amount of IgG1 in colostrum is a selectable trait, it could provide an indirect means of reducing calf mortality.

Good management practices followed by successful dairy producers have long included good sanitary procedures and the feeding of sufficient amounts of colostrum to the newborn calf as soon after birth as possible. The excess colostrum produced by some cows may be stored by freezing or for short periods by refrigeration and used to feed calves whose dams produce insufficient amounts.

More Offspring through Embryo Splitting

JOEL A. LAWITTS AND CHARLES N. GRAVES

Since the development of artifical insemination, genetic improvement in cattle has occurred largely through the widespread use of semen from superior males. The female has not been used on a large scale for genetic improvement due to the fact that the bull produces enough sperm in one ejaculation to inseminate hundreds of cows, and can therefore sire thousands of calves a year. On the other hand, a reproductively healthy cow normally produces only one egg every three weeks and, if inseminated, may produce one calf per year.

In recent years, the number of eggs that a cow produces at one time has been increased by the use of superovulation techniques. In superovulation the cow is injected with hormones which cause her to ovulate larger than normal numbers of eggs. Following fertilization of these eggs and early development in vivo, the embryos are flushed from the uterus and transferred into recipient cows or heifers. Using superovulation and embryo transfer, embryos from genetically superior females can be transferred to lower-producing cows or heifers. In this way, the superior female can be used in a greater capacity to improve the herd by producing larger numbers of calves each year.

Another procedure to increase the number of offspring produced by a cow at one time is the practice of dividing the embryos in half to produce identical twins. The ability of the half embryo to survive is only slightly less than that of the whole embryo, and thus the percent of pregnancies per whole embryo usually increases when the embryos are split and the two halves transferred. In a recent Illinois experiment in which bovine embryos are halved and then transferred, 60 percent of the recipients were diagnosed pregnant at 60 days post-transfer. The number of pregnancies was thus 120 percent of the initial number of whole embryos.

In our laboratory, experiments are being conducted to determine the optimal stage at which to divide the early embryo. These initial experiments are being conducted with mouse embryos which are very similar to bovine embryos. In these studies we have been dividing mouse embryos in half at the 2-cell, 4-cell, 8-cell, and morula (16-32 cells) stage and have been growing them in culture dishes up to the blastocyst stage, which is the next developmental stage following the morula stage. At the same time, we cultured whole, undivided embryos at each stage (2-cell, 4-cell, 8-cell, and morula) to the blastocyst stage.

When we compared the ability of the whole and half embryos at the 2-cell stage to culture to blastocysts, 80 percent of the intact embryos developed to the blastocyst stage compared with 70 percent of the half 2-cell embryos. At the 4-cell stage, 91 percent of the whole 4-cell embryos developed to the blastocyst stage, compared with 75 percent of the half embryos. The percent of 8-cell embryos which developed into blastocysts was high, 98 percent of the whole embryos developed, compared with 96 percent of the half embryos. The success of culturing half morulas to the blastocyst state was somewhat less than that of culturing half 8-cell embryos. While 100 percent of whole morulas developed to the blastocyst stage, only 75 percent of the half morulas developed.

These results shown in Figure 1 indicate that the 8-cell stage is the optimum time to divide the early embryo. When embryos were divided at this stage, the percent of half embryos which developed (96 percent) was not significantly different from the percentage of whole embryos (98 percent) which developed to the blastocyst stage in vitro. This means that if you divide the embryo at the 8-cell stage, you end up with almost twice the number of viable embryos as compared to the original whole embryos.

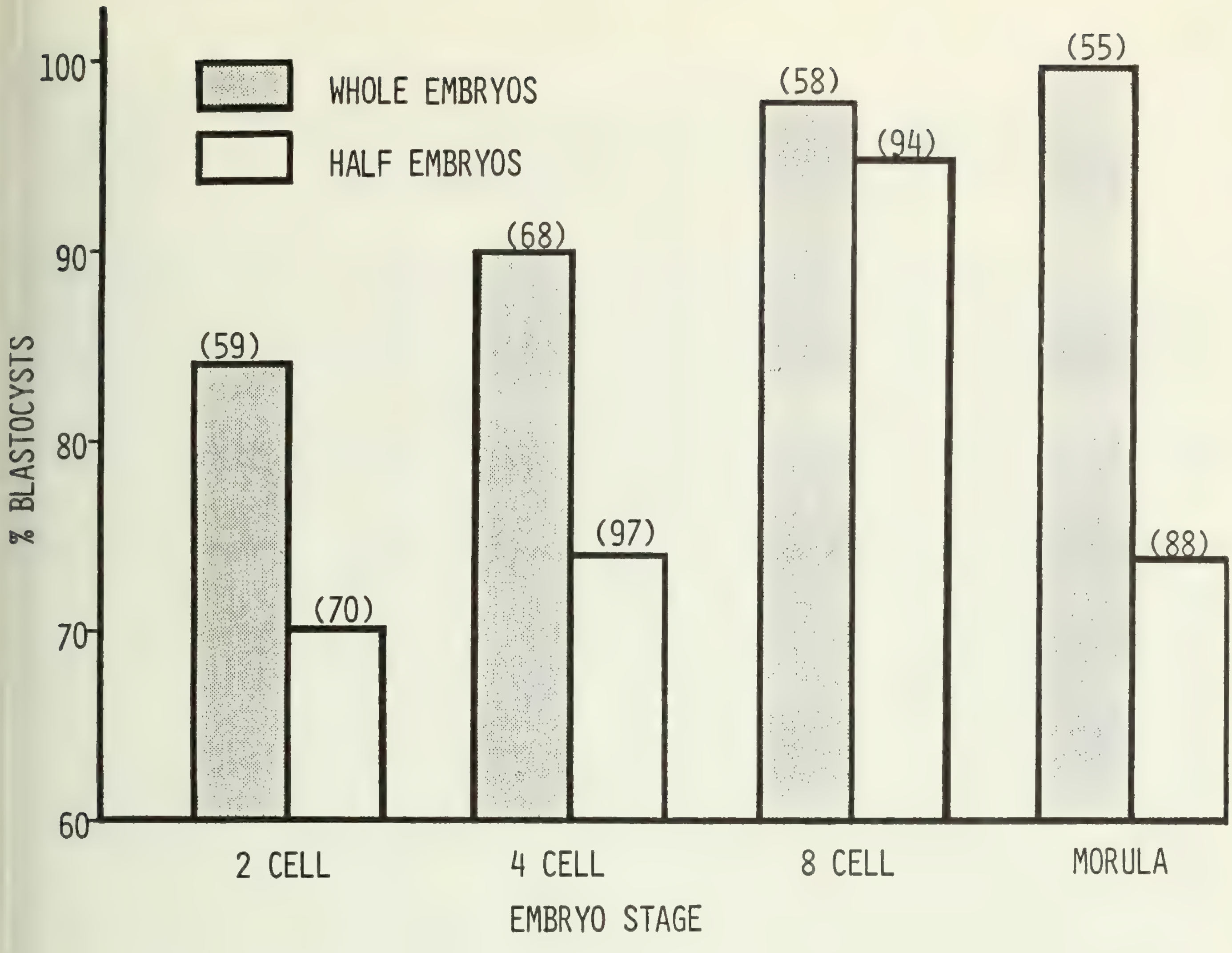


Figure 1. The percentage of whole and half embryos developing to the blastocyst stage in vitro from the 2-, 4-, 8-cell, and morula state (the number on top of each bar is the number of embryos utilized in each treatment).

To further determine if there is an optimum time to divide the embryo, we have been transferring the whole and half embryos at each cell stage into the uteri of recipient mice. We can then determine what percentage of whole and half embryos from each stage go on to form live young. In a further attempt to increase the number of offspring that the female produces at one time, we are also looking at the ability of single cells from 4-cell and 8-cell embryos to develop to the blastocyst stage in vitro and to form viable young.

After these experiments have been completed in the mouse, it is hoped that they can be repeated in the cow. At the present time, however, embryos are usually divided in half at the morula or early blastocyst stage since these are the earliest stages at which embryos can be removed from the cow by nonsurgical means. To obtain earlier stage embryos, removal must be performed surgically through the oviduct. Also, at the present time, the technology is not present to consistently culture cow embryos in vitro from the early developmental stages. Research in this area is continuing, however, and in a few years it may be possible to divide the early cow embryo or to produce many offspring from a single embryo.

Changes in Spermatozoa Following Insemination

BRADLEY A. DIDION AND CHARLES N. GRAVES

In the bovine, as in all species, a sperm cell must reside in the female reproductive tract for a period of time before it is able to penetrate an ovum. During this time the sperm undergoes a maturation phase, or capacitation, which causes changes to occur in the membrane covering the sperm head and allows the sperm to undergo an acrosome reaction (AR). Two types of AR can occur: (1) a true AR whereby the acrosome (a cap-like structure which covers the anterior portion of the sperm head) undergoes changes and releases enzymes which digest a path through the various coverings around the ovum; or (2) a false AR in which the acrosome is lost as an intact structure following cell death. Since a true AR occurs only to live sperm, these sperm are the only ones which are involved in the fertilization process.

Our interest in the AR is two fold: first we are involved with in vitro fertilization experiments and are interested in the physiological changes which a sperm cell must undergo in order to fertilize an ovum; secondly, we want to know what determines the fertility level of a bull, why one bull is more fertile than another, and if the timing of capacitation and AR are associated with fertility. In most studies in which the AR of bovine spermatozoa is assayed, any distinction between the true and false AR is not made, and thus it is impossible to distinguish those sperm which were alive when they underwent the AR from those on which the AR occurred after death.

We have now developed a sequential staining procedure for use with bull sperm that allows a distinction to be made between sperm possessing a true and false AR. By differentially staining specific structures on the sperm head, this sequential staining procedure enables us to distinguish among: (1) a dead sperm with an intact acrosome, (2) a dead sperm with a reacted acrosome (false AR), (3) a live sperm with an intact acrosome, and (4) a live sperm with a reacted acrosome (true AR).

This staining procedure has now been utilized in a study designed to determine what happens to sperm following insemination, the time required for bovine sperm to undergo capacitation, and the AR following deposition in the female tract. The sperm were recovered from the cow at various times following insemination by utilization of a catheter similar to that used for the recovery of embryos. The results indicate that for cows in estrus, capacitation and the true AR occur in some sperm within three hours following insemination and in most sperm within six hours. In contrast, recovery of sperm from cows in diestrus (cows not in estrus) showed that few sperm underwent a true AR even at six hours and that most of the sperm which were recovered were dead and had not undergone AR. These results imply that in estrus cows, the sperm of some bulls undergo capacitation and a true AR occurs very rapidly and that the induction of these physiological changes of sperm is influenced by substances present in the female tract at different stages of the estrous cycle. Experiments are now underway to determine if the length of time required for the sperm to undergo an AR is related to their fertility.

Getting the Most from Computerized Grain Dispensing Systems

SIDNEY L. SPAHR, JAMES B. LEVERICH, HOYLE B. PUCKETT, AND ERROL D. RODDA

The popularity of computer-controlled grain dispensing systems and their many options has raised the question of which features are most important, and how the systems should be used. How much advantage is there to a dual-feed system? How often should grain allocations be updated? What kind of ration balancing program is needed to complement computerized grain dispensing when all the cows receive their forage free-choice from a feed bunk?

These questions were studied in a recent 14-week trial conducted at the University of Illinois. Seventy-five cows were assigned randomly to 4 treatment groups (Table 1). Groups 1 and 2 received their grain from a dual-feed dispenser system, while Groups 3 and 4 received their grain from a single-feed dispenser system. The same feed ingredients were used for both dispensing systems (ground shelled corn and soybean meal supplemented with a mineral mix and vitamins A and D). The dual-feed system could dispense the 2 feeds in varying ratios to allow a separate protein percentage in the grain dispensed to each cow. The grain allocations for Groups 1 and 3 were adjusted weekly, while those for Groups 2 and 4 were adjusted monthly. Ration adjustments were made by the Illini Ration Balancer, an individual cow balancing program that considers estimated forage intake of the cow, nutrient content of the forage, and the NRC nutrient requirements of the cow based on her body weight, daily milk, fat percent, and growth (1st and 2nd lactation). Forty-four cows were used to test the treatment effects on cows that were past peak milk yield. The remaining 31 cows were assigned to their treatments by freshening date during the first 6 weeks of the trial approximately 2 weeks after freshening to test the effects of the treatments during early lactation. The forage was 50 percent corn silage and 50 percent alfalfa haylage (DM basis).

Table 1. Experimental Design

	Frequency of balancing	
Feeding system	Weekly	Monthly
Dual feed	Group 1 (19)	Group 2 (20)
Single feed	Group 3 (18)	Group 4 (18)

Number of cows in each group in parentheses.

Results from the cows beyond peak yield are summarized in Table 2. There were no significant differences due to the type of dispensing system or to the frequency of balancing in any of the variables. One encouraging result of this trial was the exceptional persistency of the cows. This result was credited to the ration balancing program which apparently predicted forage intake of the individual cows accurately enough to provide a precise allocation of grain from both feed dispensing systems.

Table 2. Effect of Type of Feeding System and Frequency of Balancing on Production Responses[1]

Variable	Type of feeding system Single-feed	Dual-feed	Frequency of balancing Weekly	Monthly	Initial Values
Daily milk (lb)	49.7	49.1	49.1	49.9	54.8
Milk fat (%)	3.62	3.64	3.68	3.59	3.42
Daily 4% fat corrected milk (lb)	47.1	46.2	45.8	47.5	49.9
Daily income-over-grain-cost ($)	4.78	4.77	4.74	4.81	5.58
Body weight (lb)	1,258	1,269	1,269	1,258	1,263

[1]Treatment values are least squares means for a 12-week period adjusted for initial values during a 2-week standardization period, for lactation number, and for interactions between type of feeding system and frequency of balancing.

The effect of type of feed dispensing system and frequency of balancing on the production variables at differing stages of lactation was studied by comparing the production responses for each group at various stages of lactation. No overall advantage for the entire period was found, but a significant stage of lactation by treatment interaction was present for milk production and for income-over-grain-cost. The dual-feed dispensing system with weekly balancing resulted in increased production between weeks 3 and 8 (Figure 1).

Figure 1. Daily milk production by weeks for each treatment group.

One feature noted by plotting the results by stage of lactation was that the groups with monthly balancing were more consistent in almost every variable from week to week than were the groups balanced weekly. In retrospect, this is not surprising since feed changes were taking place more often. This response is desirable when cows are in the peak part of their lactation (first 4 to 6 weeks) since it will encourage a high pre-peak production. However, after peak daily production is reached, some slight overfeeding is desirable to encourage persistency and simultaneously to allow body weight gain.

We concluded from the trial that an individual cow ration balancing program with intakes predicted from body weight and daily milk yield was an important item in getting the most from a computerized grain dispensing system. A dual-feed dispensing system and weekly balancing appeared to be advantageous only during early lactation, an advantage which largely disappeared by about 8 weeks into lactation. Since the dual-feed system offers greater opportunity than the single-feed system for individualizing both the energy and protein to cows of widely different daily yields, some additional savings in feed costs may occur with its use when cows have a wider range of daily production than was present in this trial (cows were in early lactation) or when forages are fed with markedly different protein and energy content from those fed in this trial.

Changes in Milk Production and Composition Resulting from Feeding

RAYMOND G. CRAGLE, MICHAEL R. MURPHY, AND SHELDON W. WILLIAMS

For a number of years the marketing of milk in the United States has been oriented toward the fluid milk market but this is changing. There is a growing interest in the development of a multiple component milk market as a way of equitably compensating dairy producers for the solids that they produce. Along with the development of a multiple component market, efforts are also underway to raise the national minimum standards for total milk solids from 11.5 percent to 12.0 percent. At least a part of the driving force for developing a multiple component pricing system and for increasing total milk solids in milk comes from an increasing consumer demand for cheese.

The percentage of the national milk production used to make cheese has increased steadily over the last decade, reaching 30 percent in 1983. With an increasing emphasis on the production of milk solids, it is timely to examine changes that can be brought about in milk protein and fat production, as well as total milk production through feeding, and to relate these changes in production of milk and milk components economically to increased feed intake.

To address the question of effects of feeding on the production of milk and milk protein and fat, data from 22 research reports were evaluated. These reports represented feeding and management conditions in practical use by dairy producers. The 1,105 cows used in these studies were 98 percent Holstein but the summarized results should apply for all breeds.

The results from 252 cows which were on treatments for full lactations will be of interest to dairy producers. These cows were on two feeding treatments (low ration versus high ration). The average increased feed given to the high ration treatment cows and the increased milk production resulting from feeding high rations are given in Table 1.

Table 1. Production and Feed Intake for Cows Fed High and Low Rations for Whole Lactations

	High	Low	Difference (High minus low)
Milk production (lb/day)	54.2	46.3	7.9
Milk protein (lb/day)	1.76	1.48	.28
Milk fat (lb/day	1.76	1.59	.17
Milk protein (%)	3.25	3.20	.05
Milk fat (%)	3.25	3.42	-.17
Feed dry matter intake (lb/day)	39.7	35.9	3.8
Feed crude protein (lb/day)	6.2	5.3	0.9
Feed protein (%)	15.6	14.8	0.8

Several points should be made about the data in Table 1. The cows fed the high rations produced 17 percent more milk which had a higher protein percentage (+.05 percent) and a lower fat percentage (-.17 percent). The average of 7.9 pounds more milk per day produced by cows on the high rations was the result of 3.8 pounds of additional dry matter intake and 0.9 pounds of additional crude protein intake.

To illustrate the economics of the data in Table 2, we will assume that the producer is receiving $12.50/100 pounds for milk that has 3.5 percent fat and 3.2 percent protein. We will further assume that the producer receives 16.2 cents per point for fat in milk that contains more than 3.5 percent and the same deduction if below 3.5 percent fat. The producer also receives 13 cents per point for protein in milk that contains more than 3.2 percent with no deduction for milk with less than 3.2 percent. The value of milk produced from cows fed the high and low rations can be seen in Table 2.

Table 2. Value of Milk from Cows on High and Low Rations

High ration		
54.2 lb of milk at $12.50/100 lb	=	$6.78
.5 point protein at 13¢/point (.542)*	=	.04
-2.5 points fat at 16.2¢/point (.542)	=	-.22
		$6.60
Low ration		
46.3 lb of milk at $12.50/100 lb	=	$5.78
No protein adjustment		----
.8 point fat at 16.2¢/point (.463)*	=	-.06
		$5.72
Return per cow per day: High ration		$6.60
Low ration		5.72
Increased return/cow/day		.88

*Decimal fraction of 100 lb of milk or the average production per cow per day.

Dairy farmers will be interested in the extra feed costs for the high ration. These cows consumed 3.8 pounds more dry matter and .9 pounds of protein. Using corn valued at $7.00 and soybean meal $12.00 per hundred, the extra feed costs 39 cents per cow per day. Therefore, on a fluid milk market 88 cents worth of extra milk was produced per cow per day at a feed cost of 39 cents, or a milk return over feed costs of 49 cents per day per cow.

But not all milk is sold on a fluid market. In Table 3 the value of milk on high rations versus low rations is examined from component and end-product pricing views.

Component and end-product pricing systems vary from market to market. Maximum somatic cell counts, minimum solids standards, and payment for solids-not-fat instead of protein are frequently incorporated into payment procedure. Using the data and examples found in Table 3, dairy managers can calculate their own production returns.

Table 3. Summary of Extra Returns High Ration versus Low Ration under Component and End-product Pricing Systems

	Protein			Fat	End-product* (cheese)
	$.13/point	$.20/point	$.25/point	$.162/point	(Protein + fat)
High ration (54.2 lb milk)	$2.29	$3.52	$4.40	$2.85	7.96 (3.98 + 3.98)
Low ration (46.3 lb milk)	1.92	2.96	3.70	2.58	6.93 (3.34 + 3.59)
Difference	$ .37	$ .56	$ .70	$ .27	1.03

*Dried whey value is usually equal to the cost of recovery and is not considered here.

Qualitative Genetics in Dairy Cattle Breeding

ROGER D SHANKS

"Numbers, numbers, numbers" is often heard in discussing dairy cattle breeding. Numbers, specifically predicted differences and cow indexes, are very important, but there are also many traits that are more simply inherited. The branch of dairy cattle breeding that studies these traits is called qualitative genetics. Examples of these traits are: red and black coat color, polled or horned cattle, and undesirable disorders of mule foot, rectal-vaginal constriction, limber leg, and many others. Fortunately, most of the undesirable traits are at relatively low frequencies in the general cattle population.

These traits have a genetic basis and the frequency of each can be increased or decreased through selection. Genetic inheritance is known because breeding tests and prior research have shown that families tend to have very similar responses in each of these traits, that inbreeding increases the appearance of several of the disorders, and that the disorders are present under different environmental conditions. A nongenetic cause of these disorders would have been suggested if the ration or environment influenced the appearance of the disorder.

In Holsteins, red coat color is recessive to the black, dominant coat color. In qualitative genetics notation, we might represent a red animal as rr to indicate that the genotype is homozygous recessive. In similar notation, the black animal would be represented by two genotypes, those being RR and Rr. This notation is useful to visualize two alleles (letters) for each trait. One allele comes from each parent. Offspring from a red female and a red male should all be red (mating rr x rr in Table 1). However, the black coat color cannot be predicted with certainty among matings of black males and black females because some of the black individuals may be carriers (mating Rr x Rr in Table 1). Black is considered dominant to red coat color. One-quarter of the offspring from black carrier males and black carrier females is expected to be red, and the other three-quarters of the offspring will be black. If a red calf is born to two black parents, then *both* parents are carriers and half the offspring of each parent will be carriers.

Table 1. Coat Color of Offspring from Six Types of Matings

Matings	Phenotype Genotype	Black RR	Black Rr	Red rr
RR x RR		All	...	..
RR x Rr		One-half	One-half	...
RR x rr		...	All	...
Rr x Rr		One-quarter	One-half	One-quarter
Rr x rr		...	One-half	One-half
rr x rr		...	...	All

Polled or horned cattle is another qualitative trait. Polled is dominant to horned which implies that all offspring from matings between horned individuals will be horned and that some polled individuals will not breed true (i.e., some offspring from polled cattle will have horns).

Selection for a dominant trait (black coat color or polled cattle) can be successful, but reversions to red and horned cattle will occur from black and polled parents. This is because some of the black cattle are carriers of the red gene and some of the polled cattle are carriers of the horned gene. To the opposite extreme, selection for the recessive trait could completely eliminate black and polled cattle (with the rare exception of black or polled cattle caused by mutation).

Genotypes for the undesirable disorders of mule foot, rectal-vaginal constriction, and limber leg are all homozygous recessives. This indicates that *both* parents must be carriers

of an undesirable allele if an affected calf is born. Carrier males should not be used in a breeding program. Noncarrier males with outstanding performance are available through artificial insemination. Carrier females should not be used in superovulation and embryo transfer programs. One-half the offspring of carriers will be carriers. Offspring of carriers should not be used in breeding programs. Selection, which is the greatest tool available to the dairy cattle breeder, must be used to limit the spread of undesirable alleles. Unfortunately, increasing the frequency of undesirable alleles is much faster than decreasing the frequency.

Elite offspring may be progeny tested in an attempt to detect if they are carriers. These tests are not perfect but they estimate the probability that an animal is detected as a carrier if in fact the animal is a carrier.

Let us consider a young sire named "George". There are four types of females that he could be mated with in attempts to detect if he is a carrier of an undesirable allele. To obtain at least a 90 percent chance of detecting George as a carrier, he could be mated to 4 homozygous recessive females, 8 known carrier females, or 18 of his own daughters. The first two types of matings would only detect one undesirable recessive; matings to 18 of George's daughters would have a 90 percent chance of detecting all of George's undesirable recessives. None of these mating types have been used excessively, although obtaining 8 or more 60-day fetuses after embryo transfer of a mule foot carrier is becoming more common in some sire lines.

The method that has been most used would be to mate George to a random sample of females from the dairy population. The success of this method depends on how widespread the undesirable allele is in the population. If the incidence of homozygous recessive individuals in the population was greater than 1 percent, then a 90 percent chance of detecting George would occur if he had 50 progeny. Over 500 progeny would be necessary to detect George as a carrier if the incidence of homozygous recessive individuals were less than one-hundreth of 1 percent. In the process of detecting George as a carrier, his undesirable alleles would be spread among his daughters. If George's recent ancestors were known carriers of undesirable recessives, the risk of spreading the alleles may be too great and George should not be used in a breeding program.

The future of the dairy industry rests on the individuals selected to be parents of the next generation. Choose your sires carefully and cull your cows judiciously.

Nutritive Value of Double Crop Forages for Dairy Heifers

CHARLES M. FISHER AND EDWIN H. JASTER

Feed costs make up 55 to 60 percent of the total cost of raising dairy replacements. Feeding also affects the profit related to an animal's development and growth rate. Dairy producers who efficiently utilize available land and resources to grow feed are likely to make a profit and remain in business. One method of increasing the efficiency of the cropping and feeding operation is a double cropping forage system.

Double cropping of forages provides a means for dairy producers in the midwest to grow and harvest two crops in one year or three crops in two years on the same acreage, thus making it possible to produce a variety of crops in a short period of time. In Illinois a typical double cropping system might involve seeding a cool season annual small grain, such as oats, in early spring. The oats would be harvested in late spring or early summer and the land immediately replanted with a warm season annual such as sorghum to be harvested in the fall of that year. Dairy producers feeding dairy cattle will most likely choose the annual crops which will produce the highest yields of digestible dry matter and crude protein.

A forage double cropping system may be a desirable agronomic option for those dairy producers with year-round silage storage facilities because it: (1) provides a way to meet emergency forage needs following winter kill of such perennial forages as alfalfa or birdsfoot trefoil; (2) allows early harvest of a small grain crop (wheat, oats, rye, or barley) as silage and thus greatly reduces the risk of crop loss because of wind, rain, and hail; (3) allows the farmer to more fully utilize available land and resources; and (4) provides the farmer an alternative to alfalfa and corn silage production.

Forage quality must also be of utmost importance to dairy producers in their decisions about which forage to grow, at what rates to fertilize, and at what stage of maturity to harvest the crop. The feeding of poor quality forages to dairy heifers often results in suboptimal weight gains, general unthriftiness, and delays in breeding, conception, and entering the milking string.

The objectives of this research were to evaluate the feeding value of oat, pearl millet, barley/pea, oat/pea, and grain sorghum silages when grown under a forage double cropping system for dairy heifers.

FEEDING VALUE

In a 1983 experiment at the University of Illinois, cool season forages (oat, peas, barley/pea, and oat/pea silages) and warm season forages (pearl millet and sorghum silages) were fed to dairy heifers and the feeding value evaluated. A description of the double cropping treatments is given in Table 1.

Table 1. Double Cropping Forage Treatments During 1983

Variable	Cool season[a] Forage O	P	B/P	O/P	Warm season[a] Forage PM	S
Planting date	4/18	4/18	4/18	4/18	7/15	7/15
Days to harvest	79	79	79	79	54	54
Seeding rate (lb/acre)	68	37	72/37	48/37	25	20
Variety	Otee	3019	Morex/3019	Otee/3019	Tifleaf	Grain Milo 200
Seed cost/acre	$8.25	$10.80	$17.55	$13.80	$24.40	$11.70

[a]O= oat, P= peas, B/P= barley and pea, O/P= oat and pea, PM= pearl millet, S= sorghum.

The initial phase of the experiment involved gathering data on harvest yields and forage quality. Due to logistical problems (rain and work schedules), the cool season forages could not be harvested at an optimum stage of maturity to obtain maximum animal performance. However, on June 22 (approximate optimum harvest date), the oats and barley were in the early head stage and the peas were in the early pod-set stage when preharvest samples were taken. It was not until July 6 that the cool season crops were harvested and ensiled in plastic silo bags. Table 2 illustrates the extent of chemical changes that took place in forage nutrient content as these crops matured in the field.

Table 2. Changes in Chemical Composition of Barley/Pea, Oat, and Oat/Pea Silages with Maturity in the Field

Nutrient	Forage B/P[a]	B/P[b]	O[a]	O[b]	O/P[a]	O/P[b]
Dry matter (DM), %	14.3	39.8	10.8	31.2	10.8	31.9
	---------------- (% DM) ----------------					
NDF[c]	55.8	66.5	57.5	71.1	52.2	72.8
ADF[c]	26.7	36.1	35.5	41.0	30.0	38.9
ADL[c]	4.6	4.7	4.9	6.5	3.2	7.0
Hemicellulose[d]	27.0	30.4	22.1	30.1	22.2	33.9
Cellulose[e]	22.1	31.4	30.6	34.5	26.8	31.9
Crude protein	19.8	13.1	16.2	11.1	20.0	13.0
Ash	11.3	10.7	13.0	10.7	11.6	11.7

[a]B/P= barley/pea, O= oats, O/P= oat/pea harvested June 22, 1983.
[b]B/P= barley/pea, O= oats, O/P= oat/pea harvested July 6, 1983.

[c]NDF= neutral detergent fiber, ADF= acid detergent fiber, ADL= acid detergent lignin.

[d]NDF minus ADF.
[e]ADF minus ADL.

Forage quality was reduced as a result of delaying forage harvest 14 days. Stage of maturity at harvest has been cited as the largest single factor influencing the composition and nutritive value of forage. Early cutting results in lower yields at harvest, but a higher quality material is obtained. Large increases in the cell wall constituents (NDF, ADF, ADL, hemicellulose, and cellulose) were noted (Table 2). A slight increase in the plant cell wall content was expected because as the plant grows, there is a greater need for structural tissue. Therefore, the structural carbohydrates (cellulose and hemicellulose) and lignin increase. The neutral detergent fiber (NDF) concentration of the oat/pea forage taken at preharvest increased more than 20 percentage units.

The barley/pea forage sampled at preharvest was 9 percentage units lower in ADF as compared to this forage sampled on July 7. The ADL values for the preharvested oat/pea forage were found to be half those obtained from harvested samples. The percent dry matter in the forage increased dramatically between June 22 and July 6. Crude protein values declined sharply by the time the crops were harvested. The percent crude protein of the oat/pea forage dropped from 20 percent on June 22 to 13 percent on July 6. The chemical analyses, mean nutrient intake, apparent digestibilities, and yield of these silages are shown in Table 3.

Table 3. Chemical Analyses, Mean Nutrient Intake, Digestibility, and Yield of Forages

Variable[a]	O	P	B/P	O/P	PM	S
Composition			Percent			
Dry matter	31.2	32.1	39.8	31.9	38.5	38.8
ADF[b]	45.0	39.5	38.3	42.7	40.8	40.8
CP[c]	10.9	12.6	13.5	10.9	15.0	16.9
Calcium	.35	.41	.71	.51	.37	.44
Magnesium	.35	.32	.51	.62	.36	.40
Potassium	3.04	3.55	2.62	2.92	3.47	3.38
Intake			lb/day			
Dry matter	15.2	19.1	18.0	14.1	18.7	18.7
Digestibility			Percent			
Dry matter	56.3	64.8	54.8	51.2	64.3	60.1
Yield			lb/acre			
Dry matter	4,098	3,960	4,048	4,691	4,102	3,225

[a]O= oat, P= pea, B/P= barley/pea, O/P= oat/pea, PM= pearl millet, S= sorghum.

[b]ADF= acid detergent fiber.

[c]CP= crude protein.

The oat/pea forage out-yielded other forage treatments by 589 pounds of dry matter per acre. The dry matter yields of pearl millet, oatlage, barley/pea, and peas were found to be similar, with a difference of only 150 pounds per acre between the high-yielding and low-yielding forages in this group. Yields for the sorghum forage were lower than those of the other 5 forages. However, sorghum planted on an alternate test plot at the University of Illinois dairy farm yielded 4,000 pounds per acre dry matter. Sorghum and pearl millet crops yielded well, considering the drought conditions during the summer of 1983.

Data presented in Table 3 reveal that sorghum silage had the highest crude protein content of the forages, followed by pearl millet, barley/pea, pea, oat, and oat/pea, respectively.

Heifers, which had a mean weight of 715 pounds at the start of the trial, consumed from 1.9 to 2.6 percent of their body weight in dry matter. Average daily dry matter feed intake and digestibility were highest for the pea silage. Decreasing amounts of dry matter were consumed by heifers on pearl millet, sorghum, barley/pea, oat, and oat/pea silages, respectively.

Benefits of the double cropping forage system are relatively high yields of dry matter under drought conditions, a method to meet emergency forage needs following winter kill of such perennial forage as alfalfa, and providing the dairy producer with an alternative to alfalfa and corn silage production.

Rumen-Protected Methionine for Dairy Cows

JIMMY H. CLARK AND JOHN L. VICINI

Mixtures of essential amino acids, casein, and other proteins have increased milk and milk protein yields of dairy cows when supplied postruminally. The beneficial responses obtained when free amino acids or high quality proteins were infused postruminally have stimulated interest in developing methods of protecting amino acids from bacterial degradation in the rumen so that increased quantities would pass to the small intestine and be available for absorption. Protection of protein and amino acids has been attempted by heat or chemical treatment, by formation of amino acid analogs or derivatives, and by encapsulation. The objective of this study was to determine the effect of feeding varying amounts of encapsulated rumen-protected methionine on feed intake, milk production, milk composition, and plasma free amino acids.

Thirty (second lactation or greater) Holstein cows were used that averaged 33 days postpartum at the initiation of the study. The study was divided into a pretreatment and a treatment period. Each period was 21 days. The cows were fed ad libitum a diet consisting of 60 percent concentrate and 40 percent alfalfa-bromegrass hay that contained approximately 16 percent crude protein. The concentrate mixture consisted of ground shelled corn, 84.25 percent; soybean meal (49 percent crude protein), 13.00 percent; dicalcium phosphate, 1.50 percent; trace mineral salt, 1.20 percent; and vitamin A and D supplement, .05 percent. The concentrate mixture was divided into equal portions and offered at 7:00 a.m. and 4:00 p.m. and hay was fed at 11.00 am. Cows were adapted to the basal diet during the pretreatment period and randomly assigned to one of five dietary treatments on day 21 of the study. Treatments were 0, 250, 500, 750, or 1,500 mg of rumen-protected methionine per pound of concentrate mixture (as fed basis). The DL-methionine was coated with a pH-sensitive polymer to protect it from bacterial degradation in the rumen. The rumen-protected material was 79 percent DL-methionine. The methionine was released when the material passed into the abomasum, and the low pH of the abomasal fluid caused the protective coating to rupture.

Milk samples were taken weekly on 2 consecutive milkings and analyzed for solids-not-fat, fat, and protein. Blood samples were drawn at 8:30 a.m. and 3:30 p.m. on days 17 and 20 of the pretreatment period and days 4, 10 and 21 of the treatment period. Plasma was assayed for free amino acids by gas liquid chromatography.

Intakes of the rumen-protected methionine compound for cows fed the 5 diets averaged 0, 8.7, 16.3, 24.7 and 50.7 g/cow/day which corresponds to 0, 6.9, 12.9, 19.6 and 40.2 g of DL-methionine/cow/day (Table 1). Dry matter intake was not significantly affected by feeding the rumen-protected methionine, even at the highest concentration of 1500 mg/pound concentrate. Feeding rumen-protected methionine did not significantly affect milk yield, 4 percent fat-corrected milk yield, milk composition, or body weight.

Plasma from cows sampled at 8:30 a.m. and 4:30 p.m. did not differ in concentration of essential amino acids. Because of the lack of significant differences in concentrations of individual essential amino acids between sampling times or between days within a period, values within a period were averaged for statistical analysis. The methionine concentration in plasma was not different from the control when cows were fed concentrate that contained 250 mg of rumen-protected methionine per pound. Feeding concentrate that contained 500 mg of rumen-protected methionine per pound resulted in a nonsignificant increase in plasma methionine concentrations, whereas feeding larger concentrations of 750 or 1,500 mg of rumen-protected methionine per pound increased plasma methionine concentrations. These data provided qualitative evidence that methionine was protected from bacterial degradation in the rumen and was absorbed from the small intestine.

Table 1. Effects of Supplemental Rumen-Protected Methionine on Dry Matter Intake, Milk Yield, milk Composition, and Concentration of Methionine in Plasma

	Treatments				
	Concentration of rumen-protected methionine (mg/lb concentrate)				
Parameter	0	250	500	750	1,500
DL-methionine intake, g/day	0	8.7	16.3	24.7	50.7
Dry matter intake, lb/day[a]					
Hay	16.3	16.7	14.5	12.8	17.4
Concentrate	29.1	29.3	27.8	28.6	29.5
Total	45.4	46.0	42.3	41.4	46.9
Milk, lb/day[a]	73.8	74.7	72.2	75.6	73.3
4% FCM, lb/day[a,b]	58.8	62.8	58.6	62.1	62.3
Milk composition, %[a]					
Protein	2.93	2.93	3.00	2.93	2.87
Fat	2.76	2.96	2.65	2.98	2.85
Solids-not-fat	8.59	8.46	8.46	8.47	8.41
Body weight, lb[a]	1,261	1,214	1,230	1,219	1,254
Plasma methionine, μg/ml[c]	3.7[d]	3.5[d]	4.7[d,e]	5.9[e]	9.3[f]

[a]Values are least square covariate adjusted means using values from the pretreatment period, mature equivalent milk production, and age as covariates.

[b]Four percent FCM = (milk x .4) + (15 x fat yield).

[c]Values are least square means from plasma samples obtained twice/day on days 4, 10 and 21 of the treatment period that were covariate adjusted using values obtained twice/day on days 17 and 20 of the pretreatment period.

[d,e,f]Means with unlike superscripts in the same row and period are different ($P < .01$).

The lack of an increase in plasma concentration of methionine when 250 mg of rumen-protected methionine was fed was not due to increased use of methionine for milk and milk protein production or body weight gain because they were not increased significantly. This suggests that methionine supplied at the lowest level and portions of the methionine supplied at higher levels were degraded until the systems for methionine degradation were saturated. At this point the excess methionine began accumulating in the plasma pool. Because methionine concentrations in plasma were increased significantly at the higher levels of supplementation, either methionine was not the most limiting nutrient in these diets or the magnitude of the beneficial response from its supplementation could not be measured in yields of milk and milk protein. Furthermore, if methionine was the most limiting nutrient for these cows, increasing its supply theoretically should have decreased plasma concentrations of other amino acids. However, feeding the rumen-protected methionine did not alter the plasma concentrations of any other amino acid.

Data from this study show that the rumen-protected methionine was effective in delivering methionine postruminally in a form that increased the methionine concentration in plasma of lactating dairy cows. However, it did not significantly affect production parameters of these cows. If specific amino acids are determined to limit milk production, this method would be feasible to supply these nutrients to the cow without allowing their degradation by ruminal microorganisms.

New Rapid On-Farm Milk Antibiotic Residue Tests

R. DAVID McQUEEN

CURRENT STATUS

For more than 4 years state and milk plant laboratories have utilized the *Bacillus stearothermophilus* disc assay test, which is 5 to 10 times more sensitive to penicillin than the assay previously used. The present test is designed to detect amounts of penicillin in milk that are considered to cause an allergic reaction in sensitive people. About 0.2 percent of individual farm bulk tank milk now tests positive for inhibitory substances. This appears to be a good record. From a different perspective, however, 20 million dollars is expended yearly to collect and test milk samples and discard *milk* found to be *contaminated*. Also, delays in processing milk while awaiting test results may be a costly inconvenience at transfer stations and milk plants (3 hours for the *B. stearothermophilus* disc assay). Thus, there is an urgent need for screening tests which provide results in a matter of minutes.

The Charm Test®, now in use in several Illinois plants, uses radioactive chemicals to detect any B-lactam antibiotic (penicillin, cloxacillin, ampicillin, and cephapirin are examples), as well as oxytetracycline, chlortetracycline, streptomycin, neomycin, and erythromycin. Results are available in about 12 minutes. The recently developed Spot Test® screens for 2 B-lactam antibiotics (penicillin and cephapirin) with results available in 6 minutes. The test uses monoclonal (specific) antibodies for these drugs and will soon also be able to detect cloxacillin and ampicillin. The recently developed Penzyme® Test detects the presence of any B-lactam antibiotics in 20 to 25 minutes using special enzymes.

These rapid screening tests differ from the official *B. steareothermophilus* disc assay which determines the presence of any bacterial growth inhibitory substance. *B. stearothermophilus* is also not uniformly sensitive to all antibiotics (see Table 1). This difference is probably of little concern to dairy producers since the B-lactam antibiotics are most commonly used for udder infusion and as a group have similar sensitivites.

Table 1. Minimum Amount of Antibiotic Giving a Purple Color to the Entire Medium in the Delvotest P® Method

Antibiotic	Minimum concentration in milk
Penicillin	0.004 IU/ml
Cloxacillin	0.025 ug/ml
Nafcillin	0.010 ug/ml
Ampicillin	0.003 ug/ml
Tetracycline	0.200 ug/ml
Oxytetracycline	0.300 ug/ml
Chlortetracycline	0.300 ug/ml
Streptomycin	8.000 ug/ml
Neomycin	6.000 ug/ml
Kanamycin	18.000 ug/ml
Bacitracin	0.100 IU/ml
Erythromycin	1.750 ug/ml
Rifamycin	0.050 ug/ml
Spiramycin	1.000 ug/ml

SOURCE: GB Fermentation Industries, Inc. 1979.

Dairy producers also need simple, rapid residue tests to manage drug use efficiently. Many operators routinely submit milk from treated cows to the milk plant for testing prior to addition to the bulk tank. This is highly recommended when conditions favor prolonged drug retention (for example a severely swollen udder) or when unapproved drugs or dosages are used. Some veterinarians and producers have purchased the Delvotest P® version of the official *B. stearothermophilus* test because results are available in 2.5 hours. On-farm or veterinary office testing may result in significant savings and earlier sale of milk from treated cows, especially when high drug dosages are administered and withdrawal times would have to be estimated.

TEST DISCREPANCIES

Under most conditions the results of the Delvotest P® and milk plant tests are in good agreement. Some discrepancies have, however, occurred such as (+) farm test and (-) lab test and (-) farm test and (-) individual cow plant test but (+) bulk tank test.

One explanation is that certain bacteria can produce an enzyme that destroys B-lactam antibiotics, possibly between the time of the initial test and the time of the confirmatory test; or in one test sample and not the other, if different samples were collected or samples were handled improperly. One group of researchers also reported bacteria producing an enzyme that destroys B-lactam antibiotics in 1 of 250 samples. Testing can confirm the presence of the enzyme if doubt exists. Another situation may result from the presence of certain bacteria in milk that produce bacterial growth inhibitory substances. This situation may arise in an estimated 1 in 1,000 samples. Bacterial culture can determine if this is the case. Finally, growth of certain bacteria in Delvotest P® samples may cause the formation of acid and thus a (-) test result even though antibiotic is present. Heating the milk prior to testing can retard such bacterial growth.

The best way to avoid such conflicting results is to collect test samples in a very sanitary manner as if they were milk samples to be cultured for bacteria. Very clean containers are mandatory and samples should be refrigerated between the time of collection and testing.

When bulk tank milk is contaminated and dumped without payment, producers often assume that the plant test is in error. Table 2 lists reasons for antibiotic residues as determined in one study. Usually, the error turns out to be one of those listed in the table. Poor records, not withholding milk for the full period, and accidental transfer of milk are responsible for about 4 out of 5 residue incidents. Accidental transfer can occur in spite of high visibility markings on treated cows. Segregation of treated cows and milking them separately is the most reliable way of avoiding transfer accidents.

'able 2. Reasons Given by Dairy Producers for Positive Antibiotic Residues in Milk Shipped from Their Farms

Reason	Percent[a]
Use of dry cow preparation during lactation	32
Not withholding milk for full period	32
Calving early, short dry period	15
Accidental transfer of milk	14
Prolonged excretion	12
Contamination of recorder jars	9
Withholding milk from treated quarters only	8
Mechanical failure	6
Lack of advice on withholding period	6
Recently purchased cows	3
Milking through jars	1

[a]Reflects percentage greater than 100 percent because more than one reason was given by each dairy producer.

SOURCE: J. Booth, *In Pract.* 101-109, 1982

CHANGING DRUG USAGE

In 20 percent of the incidents, the residue was related to animal variation in drug excretion, extra-label use of drugs, or use of drugs without advice or knowledge of actual withholding time. As profit margins shrink, drug residue incidents may increase as producers use more drugs in an attempt to reduce herd mastitis and attempt to shorten milk withholding periods. The Food and Drug Administration recently prohibited use of the antibiotic chloramphenicol in food animals. This drug was widely used in coliform mastitis treatment. Levels up to 3,000 times greater than the B-lactam antibiotics could be present in milk without detection. Now more readily detectable antibiotics must be used, increasing the likelihood of detectable residues.

Intensive advertising by mail order suppliers has also resulted in increased drug use. The increased use is often of questionable economic benefit. This is especially true of clinical treatment of repeat mastitis flare-ups in herds with high *Staph. aureus* mastitis infection rates. With herd milk culture tests, the infection can be identified and "shot gun" treatment minimized.

An increase in legitimate extra-label drug use has also occurred. As herd size and livestock density increased, the opportunity for transfer of contagious bacteria and the exposure to environmental bacteria have increased. Virtually no new drugs have been developed for udder infusion since the early seventies. This has encouraged drug experimentation in problem herds which do not respond to the usual control measures.

NEW FARM TESTS

Development of rapid residue tests has not been limited to milk plants. The Delvotest P® can detect milk antibiotic residue in as little as 2.5 hours at a cost of about $1.00 per sample. A simplified farm version of the Penzyme® Test is now undergoing test marketing. The procedure requires about 15 minutes and costs about $2.00 per sample. In early 1985, 2 versions of the Spot Test® are expected to be marketed. One version will test individual cow samples, the other will test bulk tank samples in about 6 minutes at an approximate cost of $2.00 per sample.

Both the Penzyme® and Spot Test® require an investment in equipment of $100 to $300 (incubator or mixer/shaker). Thus, it is anticipated that a multiple-person veterinary practice or a group of producers may purchase the test equipment to reduce overhead costs and keep test costs low.

Milk culture and sensitivity testing, extra-label drug use, and on-farm residue testing can be employed together in a mastitis control program to enable use of the best available drug(s) for specific herd mastitis infections, minimum milk discarded, and reduced incidence of clinical and subclinical mastitis. Dairy herds with bulk tank somatic cell counts (SCC) exceeding 750,000 should initiate a *mastitis reduction program* now because the SCC standard for Grade A milk is scheduled to be reduced to 1,000,000 in July 1986. Ask your veterinarian, dairy field sanitarian, or extension adviser for advice and assistance in starting a mastitis reduction program. In most herds, it takes 1 to 2 years to substantially reduce bulk tank somatic cell counts.

1986 Illinois Dairy Report

Department of Animal Sciences
Cooperative Extension Service
Agricultural Experiment Station
College of Agriculture
University of Illinois at Urbana-Champaign

Staying Competative

1986 Illinois Dairy Days

January 13 Kankakee, Redwood Inn

14 Marengo, Cloven Hoof Restaurant

15 Freeport, Masonic Temple

15 Elizabeth, Community Building

16 Sterling, Emerald Hill Country Club

January 17 Pekin, Agricultural Center

21 Quincy, Farm Bureau Building

22 St. Libory, American Legion Hall

23 Breese, American Legion Hall

24 Teutopolis, Knights of Columbus Hall

Authors

Department of Animal Sciences, University of Illinois at Urbana-Champaign, except as noted:

SCOTT G. BIDNER, director of market development, Illinois Corn Growers Association

MARK G. CAMERON, research assistant, management

JIMMY H. CLARK, professor, nutrition

CARL L. DAVIS, professor, nutrition

PETER S. ERICKSON, research assistant, nutrition

GEORGE C. FAHEY, Jr., professor, nutrition

DAVID B. FISCHER, Extension adviser, agriculture, Clinton County

TED L. FUNK, area agricultural engineer, Effingham, Regions 8, 9, and 10

DANIEL G. GIACOMINI, research assistant, nutrition

W.R. (REG) GOMES, professor and head, reproductive physiology

MICHAEL F. HUTJENS, professor, Extension dairyman

EDWIN H. JASTER, associate professor, management

TAD KERR, area agricultural engineer, Dixon, Regions 1 and 2

TIM H. KLUSMEYER, research fellow, nutrition

R. DAVID McQUEEN, DVM, professor, College of Veterinary Medicine

KENNETH J. MOORE, assistant professor, Department of Agronomy

MICHAEL R. MURPHY, associate professor, nutrition

HOYLE B. PUCKETT, professor, agricultural engineering; research leader, USDA-ARS

JAMES L. ROBINSON, professor, biochemistry

ROGER D. SHANKS, associate professor, breeding and genetics

SIDNEY L. SPAHR, professor, management

JOHN L. VICINI, research assistant, nutrition

JERRY C. WEIGEL, vice president of nutrition, Archer Daniels Midland Company

STEVEN T. WOODFORD, research assistant, nutrition

Contents

1986 Theme: Staying Competitive

University Of Illinois Research Reports

The Department of Animal Sciences

W.R. (Reg) Gomes

During the 1984-1985 academic year, several changes took place in the administrative structure of the dairy programs at the University of Illinois. The *1985 Illinois Dairy Report* announced that the Department of Dairy Science and the Department of Animal Science would be merged into a single unit involved with all aspects of animal agriculture at both the Urbana-Champaign campus and the Dixon Springs Agricultural Center. On May 16, 1985, the Board of Trustees of the University of Illinois approved the merger, and on June 4, 1985, the Illinois Board of Higher Education ratified the formation of the Department of Animal Sciences. On July 21, 1985, I was appointed head of the new department.

As this 1986 edition of the *Illinois Dairy Report* goes to press, we are beginning plans for a sizable addition to the Animal Sciences Laboratory. When the addition has been completed and the existing structure has been remodeled, departmental faculty will move from four campus buildings into the new structure, bringing together a wealth of expertise for addressing problems in dairy and other animal industries.

John R. Campbell, Dean of the College of Agriculture, has asked me to assure you that the College and the Department of Animal Sciences will maintain a strong commitment to the dairy industry of Illinois, the teaching of students who will be the dairy leaders of the future, and the aggressive research and extension programs needed to assist in building a stronger dairy industry in both the state and nation. We seek your advice and support as we make the transition to our new academic organization.

The main office of the Department of Animal Sciences will be in 328 Mumford Hall, University of Illinois, 1301 West Gregory Drive, Urbana, Illinois 61801. Our telephone number is (217)333-1045.

The dairy faculty in the Department of Animal Sciences (listed below) welcome your comments, suggestions, and questions. We appreciate your interest in the 1986 Dairy Days Program and invite you to visit us in Urbana.

Dairy Faculty in the Department of Animal Sciences

Faculty	Specialization
Marvin P. Bryant, professor	Ruminant microbiology
Jimmy H. Clark, professor	Dairy cattle nutrition
Charles N. Graves, associate professor	Reproductive physiology
W. R. (Reg) Gomes, professor	Reproductive physiology
Michael Grossman, professor	Dairy breeding and genetics
Gerhard W. Harpestad, associate professor	Extension dairyman
Walter L. Hurley, assistant professor	Lactation endocrinology
Michael F. Hutjens, professor	Extension dairyman
Edwin H. Jaster, associate professor	Dairy cattle management
Bruce L. Larson, professor	Biochemistry and lactation
J. Robert Lodge, professor	Reproductive physiology
Gene C. McCoy, farm manager	Dairy cattle management
Michael R. Murphy, associate professor	Dairy cattle nutrition
James L. Robinson, professor	Biochemistry
Roger D. Shanks, associate professor	Dairy breeding and genetics
Sidney L. Spahr, professor	Dairy cattle management
Bryan A. White, assistant professor	Ruminant microbiology

Nutritional Strategies with a Phase Feeding Concept

Michael F. Hutjens

As milk production increases 3 percent annually per cow, and as herd averages over 20,000 pounds of milk per cow become common, great nutritional demands are placed on dairy cows. Phase feeding is an approach for designing feeding programs that is divided into five periods based on milk production, feed intake, body weight status, and gestation (Figure 1). Producers should formulate rations to match each phase in order to optimize milk yield, minimize metabolic disorders, and increase longevity.

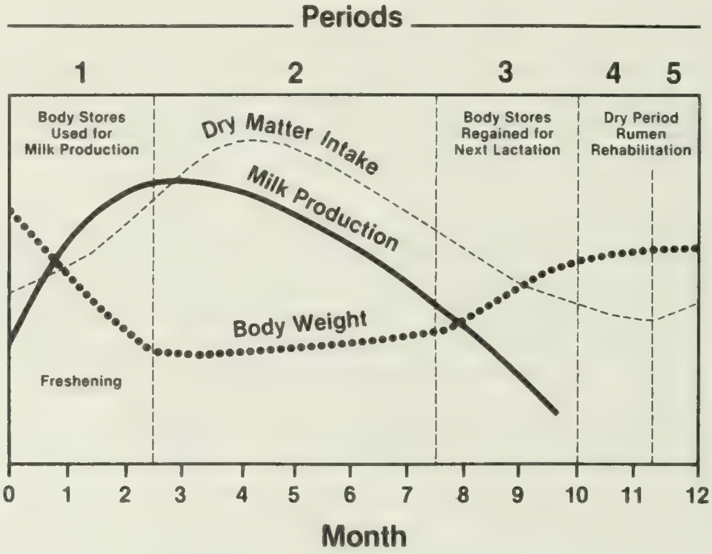


Figure 1. Nutrient and milk yield relationships in the lactation and gestation cycle.

EVALUATING PEAK MILK AND PERSISTENCY

Comparing milk yields at various times in the lactation curve provides an excellent means of analyzing the shape of the curve and determining correct milk levels for both current rolling herd averages and lactation numbers. Table 1 shows the various times in the lactation curve. Peak milk yield occurs in phase 1, four to eight weeks postpartum. Summit milk (calculated by the Mid-States Processing Center, Ames, Iowa) is the average of the highest two daily herd improvement (DHI) milk yields recorded in the first three tests. Average milk yields are calculated for three groups (less than 100 days, 100 to 200 days, and over 200 days) and measure persistency in phases 1, 2, and 3. Another way to evaluate persistency is to follow changes in the predicted 305-day production record. If these values increase as the lactation progresses, either the cows are more persistent than expected (based on DHI projections) or peak milk is not as high as it should have been (predicted too low initially), or both. Another rule of thumb is to multiply true peak milk by 200 to estimate total lactation yield.

DRY COWS (PHASE 4)

The dry period is considered a time for cows to replace lost body condition and to regenerate udder tissue. However, a sound dry cow program can increase milk yields by 500 to 2,000 pounds in the next lactation. Metabolic disorders can also be minimized through an effective dry cow program. Several key factors are discussed in the following paragraphs.

Table 1. Milk Yields at Various Stages of Lactation by Breed and Lactation Number[a]

Breed	Rolling herd average*	Lactation	Summit milk	Days in milk <100	Days in milk 100-200	Days in milk >200
			pounds of milk			
Ayrshire.........	11,400	1	42.7	40.2	33.1	26.0
	(3.9)*	2+	56.0	50.3	37.6	24.9
	13,400	1	47.5	44.8	34.7	31.8
	(4.0)	2+	64.5	61.5	42.6	28.2
	15,261	1	54.1	47.9	42.4	39.1
	(3.8)*	2+	71.1	66.6	53.3	32.3
Brown Swiss......	11,550	1	42.2	38.1	33.0	26.6
	(4.1)*	2+	56.1	50.9	39.7	27.9
	13,600	1	45.8	44.3	36.8	31.8
	(4.1)*	2+	63.4	59.9	44.6	31.3
	15,000	1	49.5	44.9	40.5	35.4
	(4.1)*	2+	68.4	64.2	49.3	35.3
Guernsey.........	10,400	1	40.0	35.1	30.0	24.9
	(4.5)*	2+	50.1	46.2	32.3	25.7
	12,500	1	45.2	41.7	35.5	30.9
	(4.6)*	2+	57.2	51.4	39.7	28.6
	14,600	1	55.9	49.8	41.8	36.6
	(4.7)*	2+	67.9	61.2	48.6	32.8
Holstein.........	14,500	1	50.4	46.8	41.8	35.3
	(3.7)*	2+	66.8	62.8	49.5	34.4
	16,500	1	55.9	51.9	47.5	40.0
	(3.7)*	2+	74.7	70.5	56.0	37.8
	19,000	1	63.4	58.5	54.7	45.9
	(3.6)*	2+	85.0	80.2	64.7	43.2
Jersey...........	10,400	1	37.0	32.6	27.4	25.3
	(4.7)*	2+	48.1	42.0	33.2	24.9
	12,400	1	40.3	36.7	31.0	28.3
	(4.8)*	2+	54.0	48.5	38.8	30.3
	15,000	1	49.1	49.3	37.0	29.3
	(4.7)*	2+	60.6	53.9	43.8	37.7
Milking Shorthorn........	11,500	1	43.1	33.9	32.4	26.5
	(3.6)*	2+	58.1	55.1	35.7	28.2
	12,300	1	48.3	43.4	35.2	31.6
	(3.6)*	2+	63.7	59.6	42.4	25.5

SOURCE: Mid-States DHI Processing Center, 1984.

[a]First lactation and second or greater lactations.
*The value in parenthesis represents the milk test at that level of milk yield.

Length of dry period

During the dry period, the mammary gland activity can be characterized as progressing through three stages: active involution, steady state involution, and lactogenesis and colostrogenesis. Ohio researchers have found that active involution begins with the cessation of milking and is completed by 30 days into the dry period. The second period does not have a clear beginning or ending point. The length of the second period is not controlled by hormones, which allow for some flexibility. Lactogenesis and colostrogensis are characterized by regeneration and differentiation of epithelial cells, selective transport, accumulation of immunoglobulin, and the beginning of secretion. The third phase begins 15 to 20 days before calving. Thus, 45 days appears to be a minimum dry period length.

Ohio researchers indicate that a minimum dry period of 58 days is required for all first-lactation cows and cows with calving intervals of 12 months or less. Fewer dry days are

needed for older cows and cows with calving intervals over 13.5 months. High-producing first-lactation cows require 10 to 20 more dry days while older high-producing cows need 5 to 10 more days. The length of calving interval has 8 to 16 times more effect on daily milk yield than do changes in the length of the dry period. The length of the first dry period is most critical. On the basis of mastitic infections, the shorter the dry period, the better.

Dry cow ration

A specific diet should be formulated to get the dry cow ready for the next lactation and to minimize metabolic disorders. Several considerations are listed below:

- Include long, dry forage in the diet (a minimum of one percent of the cow's body weight).
- Limit grain to the amount needed for meeting the energy and protein requirements.
- Protein levels of 11 to 12 percent are optimal in the ration dry matter.
- Limit calcium intake to 60 to 80 grams (large breed cows).
- Each 0.1 percent of calcium above 0.6 percent in the ration dry matter increased milk fever by 14 percent.
- Provide 35 to 40 grams of phosphorus per day (large breed cows). Each 0.1 percent of phosphorus above 0.37 percent in the ration increased milk fever by 19 percent. Blood levels of phosphorus above 5.8 milligram percent increased milk fever by 20 percent.
- Add selenium, 3 to 5 milligrams; vitamin A, 100,000 international units (IU); vitamin D, 25,000 IU; vitamin E, 200 IU; and trace minerals.
- Measure the total dry matter intake.
- Limit salt intake to one ounce per cow per day.
- Avoid high mineral intake, especially sodium-based buffer mixtures.
- Evaluate body condition scores at both drying off and at calving.

An electronic grain feeder or several groups of dry cows can allow producers to increase body condition of both thin and young cows without fattening other cows.

Body condition score

The amount of fat cover, or body condition, of a cow is one indication of her energy reserves. Changes in body condition reflect shifts in energy balance. Extremely fat cows are susceptible to fatty liver syndrome. English researchers reported that one-third of high producing dairy cows will have livers with over 20 percent fat after calving. Adequate body reserves must be available for mobilization in order to maintain high milk production. Overconditioned cows have more calving difficulties, increased metabolic disorders, and an impaired immune response. Michigan veterinarians use the term "thin cow syndrome" to describe cows that are too thin, resulting in reduced milk yield and reproductive performance. For optimum reproductive efficiency, cows must not be either too fat or too thin.

However, body condition has been difficult to evaluate. Weight changes do not account for frame size and body confirmation. Recently, Virginia researchers developed a scoring system of 1 (thin) to 5 (fat), which is summaried below. Oklahoma researchers developed a similar scheme rating cows from 1 to 9.

Condition Score 1

The individual short ribs have limited flesh covering. The bones of the chine, loin, and rump regions of the backbone are prominent. Both the hock and pin bones are sharp with almost no flesh covering and have deep depressions between them. Also, the area below the tail head and between the pin bones is severely depressed, causing the bone structure of the area to appear extremely sharp and the ligaments and vulva to be prominent.

Condition Score 2

The individual short ribs can be felt but are not prominent. The ends of the ribs are sharp to the touch but have greater flesh covering. Additionally, the short ribs do not

exhibit as distinct an overhanging shelf effect as in condition 1. The individual bones of the chine, loin, and rump regions of the backbone are not visually distinct, but are easily distinguished to the touch. Hook and pin bones are prominent, but the depression between them is less severe. The area below the tail head and between the pin bones is somewhat depressed, but the bone structure has some flesh covering.

Condition Score 3

Short ribs can be felt by applying slight pressure. Together, the short ribs appear smooth, and the overhanging shelf effect is not noticeable. The backbone appears similar to a rounded ridge, and the individual bones can be felt only when applying firm pressure. The hook and pin bones are rounded and smooth. The area between the pin bones and around the tail head appears smooth, without signs of fat deposition.

Condition Score 4

The individual short ribs are distinguishable only by firm palpation. The short ribs appear flat or rounded with no overhanging shelf effect. The ridge formed by the backbone in the chine region is rounded and smooth. The loin and rump regions appear flat. The hooks are rounded, and the span between the hooks is flat. The area around the tail head and the pin bones is rounded, with evidence of fat deposition.

Condition Score 5

The bone structure of the backbone, short ribs, and hook and pin bone region is not apparent, and subcutaneous fat depositions are very evident. The tail head appears to be buried in fatty tissue.

Cornell University researchers have used the Virginia system to evaluate feeding programs and their effect upon reproduction. They discovered that cows with severe changes in body weight between calving and 2 to 3 weeks after calving (more than 1 body weight point) had longer intervals to first ovulation and first estrus, lower first-service conception rates, and more days open. Virginia researchers noted a negative relationship between the body condition of dairy cows and the milk yield per pound of metabolic body weight. The more efficient milk producers deposit nutrients in milk, not in body weight.

For practical purposes, a score 4 dry cow may be optimal since every one pound of mobilized fat can support 6 to 7 pounds of milk (based on energy needs). Heavy cows may benefit from 6 grams of added niacin (a B vitamin). This can control or normalize body weight loss. However, do not feed niacin to score 1 and 2 cows since milk yield may be reduced. Also, avoid rapid changes in body condition scores, fat cows (score 5), and thin cows (score 1 and 2).

CLOSE-UP DRY COW (PHASE 5)

When the dry cow is within two weeks of calving, a "second" dry cow phase, or grouping, should occur. Several management options should be considered:

- Increase the carbohydrate level in the diet to adjust rumen microflora for a diet of this type. Using a portion of grain dry matter equivalent to one-half of one percent of the cow's body weight should be adequate with a maximum of one percent grain. Corn silage also is a source of carbohydrates.
- Provide some long forage to maintain rumen fill (one-half to one percent of the cow's body weight). Switch to some forage the cow will receive after calving.
- Double check calcium and phosphorus levels to avoid excesses or shortages that lead to milk fever.
- Avoid abrupt ration changes one week prepartum to one week postpartum.
- Monitor feed intake and calving activities.
- Feeding cows in the evening (5:30 p.m.) can increase calving to 76 percent between 5 a.m. and 7 p.m. when labor should be available for assistance and monitoring cows. Beef researchers suggest feeding at 10 p.m.

- In milk fever-prone cows, drop calcium intake to 13 to 18 grams four days prepartum both to activate the calcium hormonal system and to increase bone calcium mobilization.
- Consider supplementing 6 grams of niacin to cows that are heavy (score 4 and 5 cows), ketotic-prone, and high producers.
- Dramatic decreases in total dry matter intake occur 48 hours prior to calving in some cows (over 50 percent). Stabilizing the rumen and diet becomes a key factor for avoiding displaced abomasum, off-feed, and acidosis. Grain and forage intake should be monitored.

PEAK MILK (PHASE 1)

After calving, avoid abrupt changes in the feeding program. Ideally, keep the fresh cow on the close-up dry cow ration until the stress from calving and metabolic disorder has abaited. If cows are on "full feed" by 2 to 3 weeks postpartum, milk yield should be optimum. Feeding points are listed below:

- Shift to the best forage program available in order to maximize intake and digestibility. Dry matter intake is critical.
- Limit protein percent in the total ration dry matter to 19 to 20 percent protein. Higher levels may cause digestive problems.
- Attempt to meet protein needs as milk yield increases, even if grain intake lags. Mobilized body fat should be used as an energy source.
- Use lower rumen-degraded protein sources to increase protein levels to the lower gut and to improve feed utilization.
- Consider adding 1 to 1 1/2 pounds of fat (for an additional energy source) to the diets of cows that are losing body weight. Increase calcium (1 percent of the ration dry matter) and magnesium (0.3 percent of the ration matter) levels when adding fat in the ration.
- Increase grain intake 1 to 1 1/2 pounds per day after the stress of calving has eased. Shifting cows to a low T.M.R. group for several days is an alternative, but some producers shift sucessfully from the close-up diet directly to the high group. Monitor your situation to determine success.
- Add 1/4 to 1/2 pound of sodium bicarbonate (or its equivalent) as a buffer, especially in rations that are wet, ensiled, short in particle size, and high in soluble carbohydrates.
- Maintain a minimum of 18 percent acid-detergent fiber in the total ration dry matter (higher if rations are wet, ensiled, or finely chopped).
- Evaluate the physical form of the forage. Five pounds of forage over 1 to 1 and 1/2 inches in length should maintain normal rumination and digestion.
- Continue feeding 6 grams of niacin to high producing cows.
- Consider adding 120 grams of isoacids.

A successful phase 1 feeding program will maximize peak milk yield, utilize body weight as an energy source, minimize ketosis, and return cows to a positive energy balance by 8 to 10 weeks postpartum.

MAXIMUM DRY MATTER INTAKE (PHASE 2)

To avoid dramatic drops in milk yield and ketosis, maximum dry matter intake should be achieved early in lactation. However, maximum dry matter does not mean maximum grain. Associated with high dry matter intake is a shift from negative to positive energy balance; cows with positive energy balance have improved reproductive performance. Positive energy balance occurs from 6 to 14 weeks postpartum. Monitor dry matter intake to determine if the level is low. If intake values are low, review these points:

- Normally, grain levels should not exceed 2.5 percent the cow's body weight. The maximum grain per meal should be 5 to 7 pounds.
- Total mixed rations should be fed 3 to 4 times per day.
- Feed should be available 20 hours per day.

- Palatable, high quality, fresh feeds enhance intake.
- Avoid rations over 45 to 50 percent moisture.
- One hundred pounds of total feed weight may be near the maximum wet pounds (excluding pasture and green chop systems).
- Review nutrient levels (crude protein, acid-detergent fiber mineral, and vitamins) and forms (soluble protein and carbohydrate and fiber length).
- Body condition scores should be increasing.

In the forthcoming edition of their feed standards, the dairy National Research Council committee indicate that dry matter levels may be raised by 10 to 20 percent for high-producing and small breed cows. Producers should monitor and know dry matter intake values since ration changes will be needed. Milk yield and fat test can reflect the energy status of the cow since body weight reserves have been utilized.

LATE LACTATION (PHASE 3)

This phase will be the easiest to manage because the cow is pregnant, nutrient intake exceeds the requirements, and milk production is declining. The challenge is to replace lost body weight (so that cows have the optimal body condition prior to drying off), keep feed costs at a minimum, and maintain normal milk persistency. Feeding strategies are listed below:

- Shift forage/grain ratios to match nutrient needs based on milk production and body condition.
- Consider non-protein nitrogen (NPN) as a source of nitrogen (protein).
- Provide young cows with additional nutrients for growth (20 percent above maintenance for first lactation cows and 10 percent for second lactation cows).

The length of phase 3 will vary greatly. Young cows and high producing cows may never reach phase 3, while cows with a long calving interval may spend six months in the late lactation phase.

IN SUMMARY

Phase feeding forces the producer and veterinarian to recognize that each dairy has several "types" of cows, each with different needs. The manager must target where and when additives will be economically feasible, which forage types and ratios will be optional, and whether or not by-product feeds will lower total feed costs. Several benchmarks will help to monitor the success of each phase:

- Body condition (phases 1, 2, 3, and 4)
- Abnormal fat tests (phases 1 and 2)
- Peak milk production (phases 1, 4, and 5)
- Persistency of milk yield (phases 2, 3, and 4)
- Milk fever (phases 4 and 5)
- Ketosis (phases 1, 2, 4, and 5)
- Displaced abomasum (phases 1, 4, and 5)
- Off-feed and acidosis (phases 1, 2, and 5)
- Reproduction (phases 1 and 2)

Make Your Milking Herd Work for You

David B. Fischer

The future of milk production in Illinois will be directed by several factors, with the bottom line being "profitability." While the U.S. milk supply has increased 15.8 percent from 1970 to 1984, Illinois has shown an 8 percent decrease. These trends are apparent from the geographic changes that have been occurring over the last 25 years in the U.S. milk-producing areas: the west and southwestern states are increasing while the midwestern states are showing significant decreases in milk production. Some of the factors influencing the midwestern decrease include low average production per cow, slower adoption of new technologies, diversified farming methods that compete for seasonal labor, and low-yielding forage crops of marginal quality. These obstacles must be overcome if the dairy manager wants to remain competitive and continue dairying with a viable future.

Low production per cow can be attributed to a slower adoption of effective technology. There are numerous examples of dairy technology not being used to full advantage by the dairy farmer: artificial insemination (AI), production records, forage testing and ration balancing, and mastitis control programs. When using the existing technology at the present rate, the U.S. average production per cow can be expected in increase by 250 pounds of milk per year. This average represents a minimum increase of 100 pounds from genetic improvement and 150 pounds from improved management and feeding practices. At this rate, without adding any new technology, the national herd average would be 16,245 pounds by the year 2000. However, the adoption of the growth hormone for milk production could raise the national herd average an additional 25 percent by the year 2000. If Illinois dairy farmers plan to compete in the industry, they must constantly strive to improve the profitability of the milking herd.

CULLING LEVELS

Culling is a management tool that can help improve the efficiency of the milking herd. Many dairy farmers who participated in the 1984-85 Milk Diversion Program found that they had to cull more cows than anticipated in order to reduce production to meet their limits. They were able to produce the same amount of milk from fewer cows. That is efficiency! Of the two types of culling, volunteer culling is the more desirable and provides faster results in herd improvement. But unfortunately, only about one-third of all culling is voluntary (Table 1). The remainder are forced culling. For that reason, each dairy farmer should review the reasons for culling cows in order to identify management strengths and needed improvements. The major problems associated with forced culling include poor reproduction, mastitis, and udder problems. Improving management to reduce forced culling in a herd will allow an increase in volunteer culling. The more cows being culled voluntarily, the greater the improvement to be expected in herd profitability. The only exception would be in herds where the replacement heifers are sired by bulls equal to or lower in genetic potential than the older animals leaving the herd.

The surest way for dairy farmers to increase the genetic potential of their herds is to use AI on all heifers as well as on milking cows. Since it takes three years from the time of mating until the offspring enters the milking herd, the predicted difference (PD) of service sires must be higher than that of current first lactation cows in order to stay abreast with the industry. Dairy managers must be willing to sample young sires from high PD bulls. Approximately 25 percent of the herd can be safely bred to young, unproven bulls. The remainder of the herd should be bred to plus-PD proven bulls. Be selective of the young sires you choose and use them randomly throughout your herd. Relying on natural service for heifers and even more so on the entire herd will result in less genetic progress than herds using several, top AI sires. Table 2 compares the herd improvement based on AI versus non AI.

Table 1. Major Reasons Cows Leave Herd

Culling method	Cows culled (percent)
Voluntary	
Low Production	35
Forced	
Poor reproduction	29
Mastitis	12
Teat or udder injury	6
Death	5
Weak udder attachments	5
Hard milker or leaks milk	3
Feet and leg problems	2
Poor disposition	1
Other type traits	1
Ketosis	1

SOURCE: Minnesota State Dairy Herd Improvement Association, *Annual Summary 1984.*

Table 2. Effect of Artificial Insemination (AI) Versus Natural Service on Milk Production

Degree of AI (per herd)	Milk production (lb/year)	Increase in milk production above herds using all natural service (lb/year)
All natural service	13,973	---
All cows artificially inseminated	15,255	1,282
All cows and heifers artifically inseminated	16,080	2,107

SOURCE: North Carolina State University. Reprinted in "Raising Dairy Replacements," North Central Regional Extension Publication 205.

Table 3. Effect of Milk Production Per Cow on Income and Herd Size

Milk per cow (lb/yr)	20,000	18,000	16,000	14,000	12,000
Gross income[a]	$2,799	$2,538	$2,277	$2,018	$1,761
Expenses excluding labor	$2,007	$1,877	$1,761	$1,650	$1,507
Difference	$ 792	$ 661	$ 516	$ 368	$ 254
Number of cows required for $25,000 income	32	38	48	68	98
Total pounds of milk produced	640,000	684,000	768,000	952,000	1,176,000

SOURCE: Based upon *Wisconsin Enterprise Budgets, adjusted for lowered value of livestock,* Circular A2731.

[a]Based upon $12.50 per hundredweight milk and income from culled cattle.

A genetically superior replacement herd is critical to a sound culling program. With the continuing problem of surplus milk production, now is a good time to remove the lower producing females from the herd. Removing them will increase your efficiency while decreasing the amount of milk produced. Table 3 shows the impact of milk production per cow. The data show that, with a 20,000 pound herd average, a dairy manager can milk 66 fewer cows, produce 536,000 less pounds of milk, and have the same net income as a dairy farmer with a 12,000 pound herd average. Admittedly, not everyone has a 20,000 pound herd average; however, the example demonstrates that, as production increases per cow, so will profitability.

CULLING STRATEGIES

When deciding which cows to cull voluntarily, the dairy farmer should take into account both the animals' present and future profit potential. If your herd is in a dairy herd improvement (DHI) testing program, you have an excellent source of valuable information. If you are not in a milk production testing program, start now. The best time to start on a DHI record program is when times are tough and accurate decision making is of the utmost importance. DHI records can pay for themselves many times over.

Various records are needed to compare your dairy herd to a "standard" or to guidelines which are intended to identify strengths and weaknesses in your operation. Standard culling rates of cows sold for non-dairy purposes run at about 35 percent annually. Lower culling rates indicate little culling of first lactation cows and little or no genetic improvement in the herd. Higher culling rates could indicate too much forced culling (for example, death, mastitis, sterility).

Watch closely the performance of two-year-olds. First lactation cows should be expected to peak at 75 percent of milk produced as compared with second plus lactations in the herd: peak milk production has a direct influence on herd average. The culling rate for first lactation animals should be around 30 percent annually in order for you to make competitive progress with your herd. Exceptions could be seen in registered herds where type and pedigree may dictate a second chance for certain marginal producers. First lactation animals should be entering the milking herd at 24 to 25 months of age. Herds that calve heifers at an older age require a larger number of heifers for replacements. In addition, the added cost of raising replacements past 24 months plus the income lost from non-producing heifers can rob the dairy farmer of serious profits ($2 to $3 per day, per cow). Unfortunately, the Illinois average for first lactation cows from official DHI Holstein herds is 28 months.

When designing a culling program, you must establish criteria based upon accurate record keeping. The "difference from herdmates" can be a good measure for selecting potential culling candidates. Follow this method with your personal observations of mastitis, breeding, or other problems to decide whether or not an animal stays on the cull list. The daily income-over-feed-cost can tell you at what point the potential cull is no longer profitable and is ready for the truck.

OTHER MANAGEMENT FACTORS

In addition to culling, other important factors that influence herd profitability include reproduction, nutrition, and mastitis control. In reproduction, the average calving interval should be less than 390 days (13 months). Intervals greater than 13 months indicate breeding problems. The state average is 403 days (slightly less than 13 1/2 months). The desired time period from freshening to first service should fall between 50 to 70 days. The average for Illinois DHI herds is 90 days to first breeding. Also, monitoring heat detection at least 3 times a day could improve the entire reproductive summary of your herd. The best times for checking heat detection are between 9 p.m. and 6 a.m. or when most of the herd is resting and ruminating. About 75 percent of all cows will show heat signs during these hours.

In order to meet the nutritional needs of the dairy herd, dairy farmers must gain a better understanding of forage quality and ration balancing. Forage testing is necessary for ration balancing and also can save substantial protein as well as other feed-related costs. Rations should be balanced at least 4 times a year and more often when there is a noted change in either forage quality or type. Growing and harvesting high-quality alfalfa can return more milk per acre than any other crop. Added consideration needs to be given to alternative feedstuffs and their incorporation into the ration when their price is favorable.

A sound mastitis control program can significantly increase dairy farm income. Herd average somatic cell counts (SCC) should be under 250,000. If your herd exceeds an average SCC of 300,000, it's time to check the milking equipment and study your mastitis control practices. If the SCC exceeds 500,000, a serious problem exists that is causing lowered milk output. Both teat dipping after each milking and dry treating every cow at the end of her lactation are extremely critical steps for proper management.

The dairy industry in Illinois will see some significant changes in the next ten to fifteen years. One of the most obvious will be fewer dairy farms and larger herds. Illinois dairy farmers must maintain the competitive edge for profitability and subsequently, their increased milk production per cow will need to keep pace with the national herd. They can meet this challenge through the proper application of present-day technology and a willingness to adopt new technologies. Remember, the dairy industry will not stand still while dairy producers attempt to catch up. What strides dairy farmers take now to improve the efficiency of their dairy enterprises will dictate their position in the future (Table 4).

Table 4. Management Factors of Various Levels of Milk Yield

	Milk yield (pounds)			
	11,500	14,500	17,500	20,500
Cows in milk (%)	84	86	87	89
Feed cost/ cwt milk ($)	6.07	5.16	4.68	4.20
Income over feed cost ($)	744	1,088	1,401	1,769
Positive SCC (%)	42	32	24	18
PD, service sire ($)	75	81	89	92
PD, 1st lactation cows ($)	3	19	30	43
First lactation cows (%)	28	32	33	35
Cull rate (%)	35	36	37	42
Cull rate, 1st lact (%)	8	9	10	14
Average age, 1st lact (mo)	28	28	28	27
Average age, other cows (mo)	60	59	58	59
Identification, 1st lact (%)	47	65	89	91
Days dry (days)	71	65	60	57
Calving interval (mo)	13.0	13.0	13.0	13.0
Days to 1st breeding (days)	92	85	84	84
Conception rate (%)	61	57	56	53

SOURCE: Minnesota State Dairy Herd Improvement Association, *Annual Summary 1984.*

Developing a Herd Somatic Cell Count Reduction Program

R. David McQueen

The single most important cause of an increased herd somatic cell count (SCC) is mastitis or infection of the udder. In most herds 80 percent of mastitis infections are caused by contagious types of bacteria. At the end of World War II, a statewide survey of mastitis in 731 Illinois dairy herds revealed that 38.8 percent of the cows were infected with *Streptococcus agalactiae*, a contagious bacterium readily spread from cow to cow at milking. Shortly thereafter, penicillin came into common use for treatment of mastitis flare-ups, and later for dry cow udder infusion. A 1963 survey of contagious mastitis indicated *Strep. agalactiae* infection rates had dropped to 18.3 percent. *Staphylococcus aureus*, another cause of contagious mastitis, infected 11.3 percent of Illinois dairy cows.

It was soon established that cure rates of 95 percent were usually achieved by penicillin treatment of subclinical (chronic) *Strep. agalactiae* infection in lactating and dry cows. In contrast, cure rates for lactating cows infected with *Staph. aureus*, ranged from 15 to 40 percent. Following dry cow treatment, *Staph. aureus* cure rates of 50 to 75 percent were achieved. Differing growth characteristics accounted for these differences in cure rates:

Strep. agalactiae colonizes the teat canal; grows in the milk *on the surface* of mammary duct cells; produces lactic acid, a weak toxin which causes localized tissue swelling; is usually sensitive to drugs of the penicillin group.

Staph. aureus may colonize the teat canal for many months before invading the udder; exhibits clinical flare-ups in only 20 percent of infections; *penetrates into the secretory cells of the udder* and causes scar tissue/small abscess formation; resists destruction by scavenger cells of the body (phagocytes); in some strains, produces an enzyme (penicillinase) that inactivates penicillin, ampicillin, and amoxicillin.

In the 1960's control efforts were directed at designing practical methods to reduce mastitis caused by *Strep. agalactiae*, *Staph. aureus*, and *Strep. dysgalactiae*. By 1970 the following five-point control program had been developed and repeatedly shown to be practical and cost effective:

- Dip all teats with an effective germicide after each milking.
- Treat all quarters of all cows at drying off with an effective dry cow drug.
- Milk cows properly with a properly functioning milking machine.
- Treat mastitis flare-ups with an effective drug.
- Cull cows which do not respond to either lactating or dry cow treatment.

Germicidal teat dips which were shown in field tests to be highly effective in reducing new contagious mastitis infections included hypochlorite, iodophor, and chlorhexidine. Synthetic penicillins were also developed. Some resisted penicillinase (cloxacillin, cephalothin and thus were more effective than penicillin against *Staph. aureus* infections. The benzathine derivatives of the penicillins were also developed and found to persist for about 30 days after dry cow udder infusion, thus reducing the incidence of new infections during the early dry period.

Although statewide mastitis surveys have not been conducted recently, lab records indicate great diversity of mastitis problems in Illinois herds. Some Illinois herd owners have successfully eradicated *Strep. agalactiae* and have reduced *Staph. aureus* infection rates to less than 5 percent of the cows by continuously applying the five point program. But more than half of Illinois herds are estimated to have bulk tank somatic cell counts in excess of 300,000 and about 10 percent have values in excess of 1,000,000.

The relationship between individual cow somatic cell counts and the probability of infection is shown in Table 1. Herds with bulk tank somatic cell counts consistently above 500,000 have a high probability of widespread infection due to *Strep. agalactiae*, *Staph. aureus*, and *Strep. dysgalactiae*, or some combination of these bacteria. Herds with bulk tank cell counts consistently above 750,000 may have difficulty complying with the new 1,000,000 somatic cell count standard which will be imposed nationwide in July 1986.

Table 1. Relationship of Somatic Cell Count on Composite Cow Milk and Percent Cows Infected

Somatic cell count	Percent cows infected: Pennsylvania study	Percent cows infected: Cornell study
0 - 99,000	6	5
100,000 - 199,000	17	12
200,000 - 299,000	34	33
300,000 - 399,000	45	38
400,000 - 499,000	51	58
500,000 - 599,000	67	53
over 600,000	79	61

SOURCE: W. Nelson Philpot.

Many herd owners have already sought help and started a somatic cell count reduction program to meet the new standard. From 20 to 35 percent of Illinois dairy herds have cell counts sufficiently low to qualify for milk quality payment incentives (SCC less than 300,000 to 400,000). In many such herds, *non-contagious* bacterial infections are now the most common cause of mastitis. These infections are usually mild or subclinical, but acute flare-ups due to coliform-type bacteria may occur seasonally.

The benefit to be derived from the five point program is heavily dependent upon reducing infection caused by contagious bacteria by reducing the spread to other quarters/udders at milking. Herds with high SCC frequently have not fully implemented the program. Data from the 1984 Hoard's Survey is summarized below:

- 30.9 percent prep rags
- 19.7 percent prep sponges
- 45.7 percent individual paper towels
- 91 percent prepped udders
- 65 percent used commercial udder wash
- 75.8 percent dipped or sprayed teats
- 64 percent dry treated all quarters
- 16.7 percent dry treated all quarters of all problem cows
- 11.1 percent dry treated only problem quarters
- 8.2 percent did no dry treatment

SPREAD OF CONTAGIOUS MASTITIS

Table 2 illustrates the ease with which contagious *Staph. aureus* spread from an infected cow to a non-infected cow during the various milking steps. Trials both with and without udder prep sanitizer are shown. The trial with water prep demonstrated spread to over 97 percent of teats, but the use of sanitizer (hypochlorite) reduced the probability of teat infection by only 18 percent (79 percent infected). In the sanitizer trial half of the teat bacterial contamination was due to bacteria spread by the milking unit (39 percent infected before milker attachment versus 79 percent after milking). The role of the conventional milking unit in spreading contagious bacteria is further defined in another study (Table 3). Spread of bacteria from cow 1 to cows 2, 3, 4 and 5 and to quarters 2, 3, and 4 of all cows is clearly demonstrated.

Table 2. Transfer of Staphylococcus aureus During Milking from Infected to Uninfected Cows

	Percent swabs positive for *Staph. aureus* from			
Hygiene applied	Teats before foremilking	Teats after foremilking	Teats after udder washing	Teats after cow milked
Water preparation	0	29	63	97
Disinfectant preparation, paper towels and gloves	0	16	39	79

SOURCE: F.K. Neave, NIRD.

Table 3. Transfer of Staphylococcus aureus Bacteria During Milking[a]

Cow milking sequence	Teat swabs (bacterial count) 1[b]	2	3	4
Cow 1	535	2	1	0
Cow 2	477	224	64	104
Cow 3	330	161	49	98
Cow 4	296	130	28	11
Cow 5	212	77	5	16

SOURCE: D.S. Phillips, Ruakura (N.Z.); *NMC*, 5:2 (June), 1982.

[a]Tracer studies carried out on a group of cows have shown that a conventional claw transfers bacteria between quarters and between cows. A culture of *Serratia marcescens* was infused into one teat cup of the first cow milked in a sequence of five cows. Swabs taken from the teat were incubated for 24 hours before being examined to establish the level of contamination. The table summarizes the results of 15 experiments.

[b]Infested teat cup.

The upshot of these findings is that, in herds with contagious mastitis, effective methods are needed to stop or at least reduce the spread of milk-borne mastitis bacteria. Milking infected cows (SCC above 250,000) separately or last is the obvious answer. This may appear difficult, or impossible, but acceptable methods can usually be found. In drug resistent *Staph. aureus* herds (bulk tank SCC of over 750,000), the five point control program often lowers the count to 500,000 to 750,000, but further reduction may not occur, despite heavy culling. Milking segregation, improved milking equipment, improved milking procedures and sanitization are needed to bring about further SCC decline. Recently, developed back-flushing systems also have reduced machine spread of milk-borne bacteria from cow to cow, but they are probably too costly for the average size, Illinois herd.

TEAT DIP GUIDELINES

The germicidal teat dips previously listed have repeatedly been shown to reduce the number of new contagious udder infections *(Strep. agalactiae, Staph. aureus, Strep. dysgalactiae)* during lactation by 60 to 80 percent. Several other dips (including some newer formulations) reduce new infections by 50 to 65 percent, and thus are about 20 to 25 percent less effective than iodophor, chlorhexidine, and hypochlorite. *Latex/vinyl teat sealers, which have undergone only limited field testing,* appear of limited value in reducing contagious mastitis infections (20 to 30 percent reduction). The addition of germicide has done little to improve performance of teat sealers, possibly because dip viscosity (thickness) hinders penetration of the teat canal and the killing of contagious bacteria colonizing the teat canal. Marked increases in herd SCC have often been observed in *Staph. aureus* herds following several months of continous teat sealer use.

Increases in SCC have also occurred following extended use of "cosmetic" dips, which have little or no germicidal action. Teat cups containing such dips may become contaminated with bacteria and actually spread infection. Skin moisturizing (emollient) creams that are used to reduce frost bits (including those with germicides) also are probably ineffective in reducing the spread of contagious mastitis because of limited teat canal penetration. Discontinuing use of germicidal dips to avoid frostbite or teat irritation during the winter months frequently results in increased SCC in herds with contagious mastitis. Acceptable ways must be found to dip teats, yet avoiding frostbite or irritation. Dairy farmers should consider (1) dipping with a standard germicide and allowing the dip to dry or blotting it lightly with a clean towel before turning out the cows; (2) dipping *only* the teat end with chlorhexidine and then applying a frost protectant cream containing chlorhexidine; and (3) determining the cause of teat irritation.

Germicidal teat dip should also be applied about 1 to 2 minutes prior to infusion of any quarter with clinical mastitis and before dry cow udder infusions. This will reduce the possibility of introducing secondard bacterial infections directly into the teat sinus. Application of teat dip is also advised prior to the collection of milk samples for bacterial culture, in order to kill teat end bacterial contaminates that make culture results difficult or impossible to interpret.

Daily teat dip use should be continued for about two weeks after dry off, providing dipping can be performed without causing milk letdown and leakage. In many herds, this can only be accomplished by restraining cows in facilities other than the usual milking area, and at times other than the customary milking periods.

During the dry period a marked increase in the number of *Streptococcus uberis* (an environmental bacterium) on teats occurs due to cessation of twice daily teat cleaning and dipping. As a result, the number of quarters infected with *Strep. uberis* increases during the dry period. In cows that are dry treated, this increase does not occur until the late dry period when the declining udder drug level is no longer inhibitory. Teat numbers of other environmental bacteria, such as *E. coli*, *Klebsiella*, *Enterobacter*, and *Staphylococcus epidermitis*, also increase near freshening. This is probably related to increased udder size and contamination, especially when housing sanitation is poor. *Staph. epidermitis* bacteria also readily colonize teat abrasions, which are more common on the more recumbant older dry cows. Twice daily teat dipping throughout the dry period has been shown to reduce the number of new *Strep. uberis* infections, but the practice is labor intensive and may not be cost effective. The typical germicidal dip does not provide more than a few hours protection, yet environmental exposure is continuous. Presently available teat sealers also crack after a few hours. What is needed is a prolonged action germicide/sealer that lasts

for weeks instead of hours. For the time being, dry cow sanitation/housing should receive increased attention to reduce infection due to environmental bacteria near calving.

TREATMENT

Dry cow treatment of all quarters of all cows with an effective commercial product is necessary to reduce new mastitis infections in the early dry period. Upwards of 40 percent of new quarter infections develop during the dry period. The periods of greatest susceptibility are the two weeks post dry-off and the one to two weeks prior to freshening (Figure 1). Milk may leak from infected quarters for 10 to 14 days (or until residual gland secretions are reabsorbed), contaminating bedding areas and teats of other cows/quarters. Dry treatment of all quarters of all cows markedly reduces new infections of both contagious and environmental bacteria during the early dry period. Selective dry treatment is unwise because untreated quarters lack this added protection. Also, treating only quarters with a history of clinical flare-ups misses upwards of 30 percent of *Staph. aureus* infected quarters.

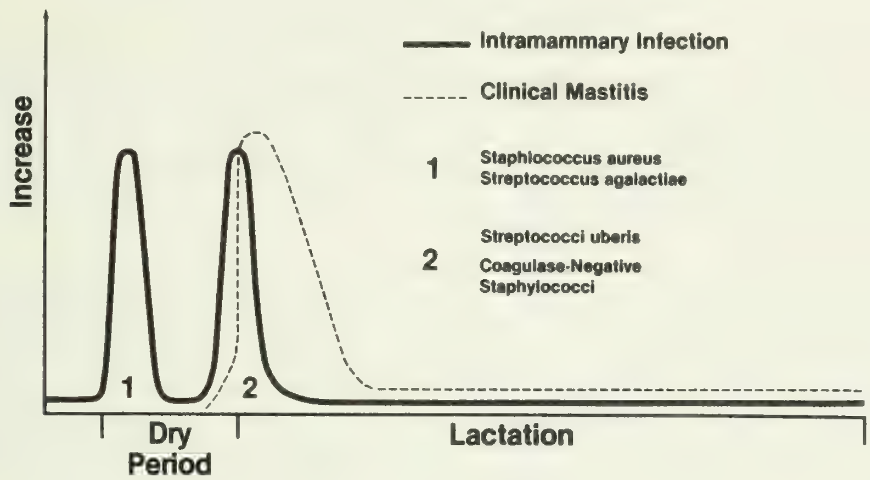


Figure 1. Incidence of new mastitis infections.

Curing infected quarters is also a key factor in reducing herd cell counts and contagious mastitis. In addition to directly lowering the SCC of previously infected quarters, a bacteriologic cure also reduces the exposure of uninfected quarters to infected milk and thus reduces the number of new infections.

Two ways to reduce the number of infected quarters are to (1) use of effective drugs (dry cow or lactational treatment) and (2) cull persistently infected cows. However, both methods cannot be used to maximum benefit without some means of identifying high SCC quarters that are probably infected. Continued monitoring of problem quarters is also necessary to identify treatment failures (persistently high SCC quarters despite treatment): for example, cows that are potential culls. A California Mastitis Test (CMT) is required for identifying and monitoring problem quarters.

As mentioned earlier, there are major differences in cure rates between *Strep. agalactiae* and *Staph. aureus* infections. Such differences dictate changes in the emphasis of the various steps in the basic five point control program, depending on the type of herd infections. For example, it is rarely necessary to cull more than 5 to 10 percent of *Strep. agalactiae* infected cows due to treatment failure; also, blitz herd treatment is cost effective in certain conditions. A milking order is desirable but not absolutely essential for an effective *Strep agalactiae* reduction program. Maximum culling and a milking order are both required to make substantial progress in severely infected *Staph. aureus* herds. Treatment of lactating cows with subclinical infections is seldom cost effective due to low cure rates. Some herds infected with *Staph. aureus* and *Strep. agalactiae* require additional adjustments.

Quarter milk sample cultures of representative high SCC cows (1/4 to 1/3 of the herd) is recommended as the first step in establishing a SCC reduction program. Once the types of infection are known, dry cow and lactational treatment strategies can be determined.

Drug resistence has occasionally been responsible for the failure of SCC reduction programs:

- *Strep. agalactiae* strains that are resistent to one or more drugs including novobiocin, erythromycin, neomycin, gentamycin.
- *Staph. aureus* strains that are resistent to one or more drugs including penicillin, ampicillin, amoxicillin, erythromycin, gentamycin, cloxacillin.
- *E. coli, Klebsiella, Enterobacter, Serratia* and *Pseudomonas* bacteria that resist one or more drugs including ampicillin, cloxacillin, erythromycin, gentamycin, neomycin, novobiocin, penicillin, cephalothin, tetracyclines, sulfas.

A bacterium shown to be resistant to a drug in the laboratory is not likely to be controlled when that drug is used in an animal. However, a bacterium's drug susceptibility in the lab does not assure the effectiveness of the drug in an animal. An example is *Staph. aureus* survival in gland secretory cells, scavenger cells, or in small abscesses despite adequate drug levels in milk.

Occasionally drugs which are effective by udder infusion are ineffective when given intramuscularly either because of inadequate dosage or because the necessary repeat injections are not given to maintain drug levels. A common example is a single penicillin injection given intramuscularly in a dose which is adequate for other infections but grossly inadequate to cure *Strep. agalactiae* infection.

Excessive drug use is also a costly problem in mastitic herds. In a *Staph. aureus* problem herd, the initial mastitis flare-up in a heifer or young cow should be treated aggressively to optimize the chance of bacteriologic cure, even though milk discard times may be increased. Subsequent flare-ups are only treated to reduce milk SCC and bacterial numbers because the odds of cure are very slim. Spontaneous cures of mastitis caused by *Strep. fecalis, Strep. fecium,* and certain other environmental bacteria are common without treatment. In herds with low SCC (under 250,000), quarters with slight swelling and a few "flakes" upon initial milk letdown should be milked out completely and observed carefully until the next milking, provided the cow remains on feed.

In herds with teat end lesions, an increase in clinical flare-ups is common. The bacterial cause may be either *Staph. aureus* or *Strep. dysgalactiae,* both of which readily colonize teat end/skin lesions. The cause of the lesions should be determined and corrected, because re-infection will rapidly occur. Dipping the entire teat also reduces bacterial colonization of skin lesions. Increased *Strep. uberis* infections in the dry period have also been observed in herds with chronic teat end lesions and buildup of *Strep. uberis* in free stall bedding. Sanitation of cows between milkings (clean dry bedding), use of teat sealers on high risk older cows during periods of high humidity, and reducing liner slip/squawk are basic to reducing environmental mastitis flare-ups, especially of coliform bacteria.

MILKING MACHINE ROLE

Herd mastitis problems are frequently attributed to milking machine malfunction, but only bacteria *cause* infections. The milking machine can assist in the spread of mastitis, but *only if bacteria are present* (see Table 3: Transfer of *Staph. aureus).* Flooding of the liners due to improper machine function, excessive drop in milking vacuum, and faulty installation cause both regurgitation of milk and reverse transport of bacteria through the teat canal into the teat sinus. Liner slips/squawks and removal of the claw or teat cups without prior vacuum shut-off result in teat-end impacts that have been shown to increase new infections due to *Staph. aureus* and environmental bacteria. In problem mastitis herds, milking machine function should be evaluated during milking, and deficiencies that have a direct relationship to mastitis should be corrected. Improving milking machine performance often reduces clinical flare-ups but *does not reduce contagious mastitis injection rates.* Mastitis reduction requires broad control efforts and a knowledge of the type of infection.

University of Illinois
Research Reports

Dairy Energy Update

Ted L. Funk and Tad Kerr

A profit-conscious dairy manager should know what it costs to produce a hundred pounds of milk. Usually, feed, labor, veterinary services, and interest amounts are major expenditures that most producers take into consideration. However, energy cost, although a smaller expense than others, also warrants close attention as the dairy farmer trims the operation for efficiency.

SIGNIFICANT ENERGY EXPENDITURES

Energy usage on the farm can be divided into two components: liquid (portable) fuel usage and electrical (non-portable) fuel usage. Two farms were modeled for this study: a 40-cow stanchion operation and a 100-cow free-stall dairy. The values for calculating each farm's energy consumption by the various tasks and operations came from published sources and were used to formulate the following assumptions:

- Production level (15,000 lb milk)
- Replacement percent (60)
- Forage yield, tons DM per acre (4)
- Grain yield, tons DM per acre (2.84)
- Silage yield, tons DM per acre (5.68)
- Alfalfa cuttings per year (4)
- Gasoline cost ($1.20/gal)
- Electricity cost ($0.06/kwh)

Liquid fuel is used on benchmark farms for forage production (alfalfa haylage and corn silage), grain production (corn), manure hauling, and farm travel. Forage production includes mowing-conditioning, baling, hauling hay, spreading fertilizer, spraying, chopping and hauling both haylage and corn silage, and operating a silo blower. Grain production includes disking stalks, spreading bulk fertilizer, chisel plowing, disking, applying ammonia, field cultivation, rotary hoeing and cultivating part of the crop, spraying, harvesting, hauling, and grain drying. Manure is hauled and spread as a semi-solid, on nearly a daily basis. Fuel for farm travel is not included in the energy costs given for this paper because the estimated values vary so much from farm to farm that it is difficult to deem an estimate as being "typical."

Fifty percent of the liquid fuel that is used goes into grain production to feed the dairy herd. Twenty-eight percent of that grain-production energy is used in grain drying (assuming removal of 10 points of moisture with a high-speed dryer). Another 24 percent of the liquid fuel total goes toward hauling manure (daily spread system). Forage production consumes the remaining 26 percent of the liquid fuel, while forage chopping alone is responsible for 10 percent. Additional fuel is used for miscellaneous tractor use and farm pickup travel.

Electrical usage includes milking, milk cooling, water heating, space heating, replacement raising, feed processing, feeding, and lighting. Within electrical energy usage, water heating is the biggest single item (33 percent). Next comes milk cooling (23 percent), milking (13 percent), and raising replacement heifers (15 percent). The respective per-unit costs of energy on the 40-cow and 100-cow "typical" farms were $0.70 and $0.66 per hundredweight of milk. A study of 14 dairy farms in Vermont (John Stephenson, *The Dairy Farm Energy Book*, Brieflet 1308, University of Vermont Extension Service, 1981) ranging in size from 30 to 180 cows showed a variation in energy costs of between $0.50 and $1.12 per hundredweight of milk. These figures included farm truck travel and miscellaneous tractor use. The 14 dairy farms, after examining their energy usage and making cost-effective changes, saved an average of 20 percent on their liquid fuel expenditures and 24 percent on their electrical bills.

FACTORS AFFECTING PER-COW ANNUAL ENERGY USE

The following items are major factors that affect per-cow annual energy use:

- *Number of animal units and type of enterprise.* The benchmark herds show the liquid fuel and electrical energy usages given in Table 1.

Table 1. Annual Energy Usage on Benchmark Farms

Item assumption	40-cow stanchion	100-cow free stall
Number of cows	40	100
Replacement percent	60	60
Total animal units	52	130
Milk production/cow	15,000	15,000
Tons forage per cow	4.2	4.2
Tons grain per cow	2.1	2.1
Forage requirement, DM tons	218.4	546
Grain requirement, DM tons	109.2	273
Forage yield, t/acre	4	4
Grain yield, t/acre	2.84	2.84
Silage yield, t/acre	5.68	5.68
Alfalfa cuttings/yr	4	4
Alfalfa total acreage	27.30	68.25
Alfalfa hay acreage	13.65	34.13
Alfalfa haylage acreage	13.65	34.13
Corn ac. for silage	19.23	48.08
Corn ac. for grain	38.46	96.15
Forage production, liquid fuel		
Mower-conditioner	98.28	245.70
Baler	40.95	102.38
Hauling hay	10.92	47.78
Fertilizer spreader	30.58	76.44
Spraying (50%)	2.87	7.17
Chopping haylage	98.28	245.70
Chopping corn silage	100	250
Hauling haylage	16.38	81.90
Hauling corn silage	38.46	158.65
Blower	57.57	143.93
Total (gallons gasoline equivalent)	494.29	1,359.64
Corn production, liquid fuel		
Disk stalks	36.35	90.87
Spread fertilizer	16.15	40.38
Chisel plow	100.96	252.40
Disk early	44.42	111.06
Apply NH3	56.54	141.35
Field cultivate	48.46	121.15
Plant	40.38	100.96
Rotary hoe (20%)	4.04	10.10
Cultivate (50%)	14.13	35.34
Spray (50%)	6.06	15.14
Harvest corn	86.54	216.35
Haul 1 mi (50%)	4.81	12.02
Haul 5 mi (50%)	2.88	7.21
Grain drying (10 points)	578.22	1,445.54
Total (gallons gasoline equivalent)	1,039.95	2,599.87

Table 1.—continued

Item assumption	40-cow stanchion	100-cow free stall
Manure hauling, liquid fuel		
Solid system, daily	439.92	1,404.00
Total gasoline equivalents	1,974.15	5,363.50
Total gasoline equivalent per animal unit	37.96	41.26
Total gasoline equivalent per cwt	33.00	36.00
Electrical energy		
Milking	3,910.71	8,150.00
Milk cooling	6,000.00	15,000.00
Water heating	11,056.46	17,447.44
Parlor space heat*	1,000.00	3,650.00
Replacement raising*	5,136.00	8,040.00
Feed processing	853.94	2,134.86
Feeding forage & concentrate	81.90	204.75
Lighting*	2,000.00	2,600.00
Total electrical consumption, kwh	30,039.02	57,227.05
Electrical consumption per animal unit	577.67	440.21
Electrical consumption per cwt of milk	5.01	8.82
Energy costs		
Gasoline, $/gal	1.20	1.20
Electricity, $/kwh	.06	.06
Cost per animal unit	80.22	75.92
Cost per cwt of milk	.70	.66

*Values marked with an asterisk are taken directly from John Stephenson, *The Dairy Farm Energy Booklet*, Brieflet 1308, University of Vermont Extension Service, 1981.

- *Feed sources.* Energy use for growing feed on the farm would be balanced against a higher cost of purchased feed. The benchmark farms grow their own forages and corn.
- *Culling rate, replacement numbers, and first-calving age.* High culling rates, large numbers of replacement animals, and late breeding of heifers significantly increase the farm's energy use per animal unit and per hundredweight of milk.
- *Manure handling strategy and equipment.* Although liquid storage and handling facilities conserve more usable nutrients than semi-solid facilities, the semi-solid methods use considerably less fuel for hauling and spreading.
- *Forage systems.* To harvest and store alfalfa, a haylage system requires about 56 percent more liquid fluid per acre than a square bale system.
- *Grain drying systems.* High temperature grain drying systems require about twice as much total energy compared with low temperature systems.
- *Farm size and distance to fields.* Fuel for the farm pickup is not included in the figures for the benchmark farms. Field equipment burns a considerable amount of fuel in traveling between fields.

ENERGY USE BREAKDOWN BY SIZE

Milking, milk cooling, and water heating account for more than two-thirds of the benchmark farms' electrical energy usage. The largest users of liquid fuel are grain drying and forage production. Consider the following suggestions for reducing energy costs in those areas.

MILKING ENERGY

The primary energy users in the milkhouse are the vacuum pump (or pumps), the milk cooler compressor, and the water heaters. Select vacuum pumps carefully. It's a mistake to have too little vacuum pump capacity, but having pump capacity far in excess of the milking equipment manufacturer's recommendations costs more than just the initial investment. A 100-cow operation milking in a double-four herringbone parlor with two 3-hp vacuum pumps would spend 15.3 kwh more annually per cow than with a 5-hp pump. If the extra horsepower isn't needed for proper milking system operation, that's an electrical energy cost difference of $92 per year (at $0.06 per kwh) to have a "backup" vacuum pump and excess capacity. The energy consideration may not be as important as the reliability of the milking system, but substantial investment and operating cost differences do exist between the systems.

MILK COOLING EFFICIENCY

It's only logical that less electrical energy should be needed to cool milk when the weather is cool than in the middle of summer. Figure 1 shows the kilowatt-hours required per hundredweight of milk cooled at various ambient (outdoor) air temperatures. This calculation assumes an air-cooled condenser with clean fins and with free air movement around it. Dirty fins or poor air movement restrict heat transfer from the condenser and affect cooling performance much the same as warmer weather does: they both cost money in the form of higher electric bills. Consider an example where restricted air movement around the condenser produces the equivalent of a 10°F higher than normal ambient air temperature. For a 15,000 pound herd average, this 10 percent excess energy for cooling milk translates to 150 kwh per cow per year. At $0.06 per kwh, that's $9 per cow charged up to unnecessary milk cooling energy. The bottom line is "keep your air-cooled condenser clean and its airflow unrestricted."

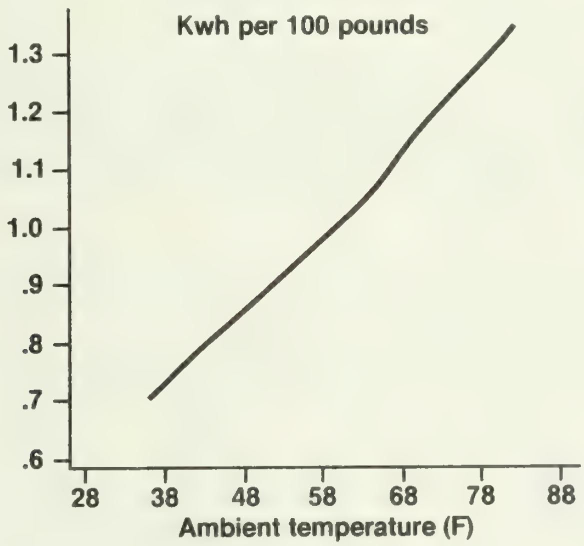


Figure 1. Energy consumption (kwh) per 100 pounds of milk cooled at various ambient temperatures.

SOURCE: USDA, A Guide to Energy Savings for the Dairy Farmer, 1977.

PRE-COOLING WITH A PLATE OR TUBE COOLER

Another way to cut milk cooling energy consumption is to use well water to pre-cool the milk about 20°F before the milk goes into the tank. A plate or tube cooler will save about 1 kwh of electricity annually for each pound of milk cooled per day. For example, the 100-cow, 4,100-pound per day producer can save 4,100 kwh per year, or $246 with electricity at $0.06 per kwh, with milk pre-cooling. If the producer wants to pay off the pre-cooler in 5 years with 10 percent interest on the investment, then the producer can afford to spend about $930 on the entire pre-cooling system on the basis of reduced cooling energy alone.

At $0.10 per kwh, that producer can spend up to about $1,550. One situation where a pre-cooler might be a wise investment is when the existing refrigeration system capacity is insufficient, such as in remodeling a parlor to increase cow throughout. Pre-cooling the milk 20°F could save the expense of purchasing a larger refrigeration system. A pre-cooler typically takes about 2 gallons of water for each gallon of milk cooled, or 24 gallons of water per hundredweight of milk, so a good water supply is needed as well as someplace to utilize all that tempered water. (It is illegal to put the tempered water back into a well.)

WATER HEATING/MILK COOLING VIA HEAT EXCHANGER

An energy conservation step beyond exchanging heat directly between cold well water and warm milk (as in a pre-cooler) is through the use of a water-cooled refrigeration heat exchanger. The waste heat dumped by the milk refrigeration unit amounts to about 80,000 BTU's of energy for every 1,000 pounds of milk cooled; that energy is the equivalent of about 23 kwh of electricity or 1 gallon of LP gas. Part of this energy comes from the compressor and shows up as heat in the refrigerant fluid. The heat exchanger takes heat from the refrigeration system and puts that heat energy into water for use in the dairy facility. By using compressor heat and milk heat to warm water for the parlor, some of the energy can be saved that would normally be "dumped" outdoors.

There are two basic types of refrigeration heat exchangers on the market today: the desuperheater type and the complete condensing type. See Figures 2, 3, and 4 for diagrams of how these units fit into the milk cooling and water heating systems. The desuperheater does not replace the existing air-cooled condenser in the system and will not heat as much water as the complete condensing exchanger. The complete condensing type replaces the existing air-cooled condenser and can provide higher water temperatures. Some models can store hot water at two different temperatures, 100°F for udder preparation and 140°F for pipeline washing.

Refer to Tables 2 and 3 for approximate annual savings with add-on (desuperheater) and complete condenser heat exchangers. These tables assume that a dairy uses all the hot water produced by the heat-recovery process and that assumption may not be completely valid for some dairymen. Table 4 shows how much the benchmark farms can afford to pay for a heat exchanger.

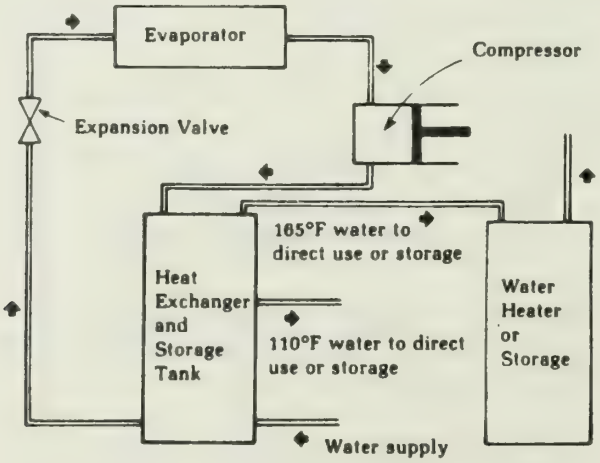


Figure 2. Complete-condensing heat exchanger producing two different water temperatures.

SOURCE: Northeast Regional Agricultural Engineering Service, Publication FS-18, "Dairy Farm Heat Exchangers for Heating Water," April, 1979.

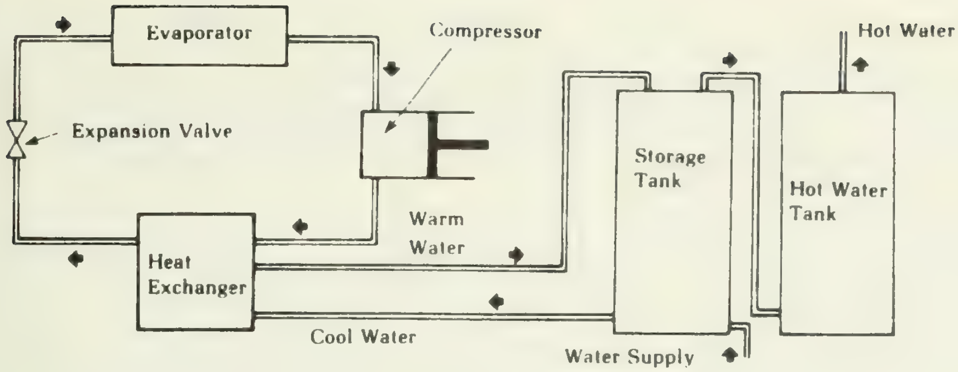


Figure 3. Complete-condensing heat exchanger which eliminates air-cooled condenser.

SOURCE: Northeast Regional Agricultural Engineering Service, Publication FS-18, "Dairy Farm Heat Exchangers for Heating Water," April, 1979.

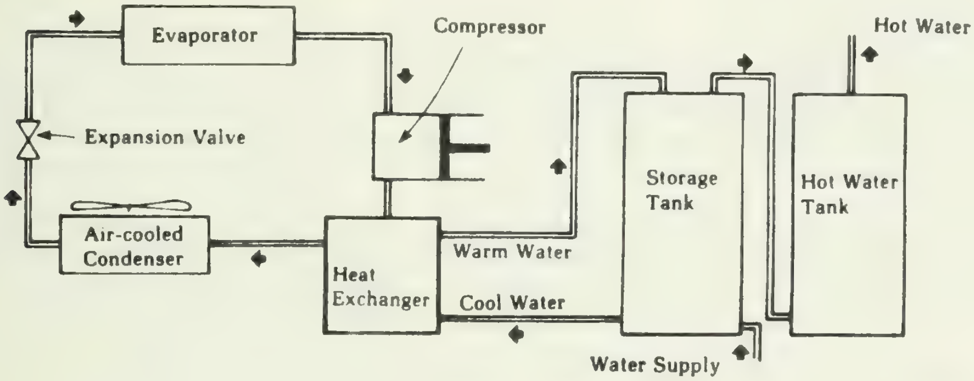


Figure 4. Desuperheating heat exchanger which retains present air-cooled condenser.

SOURCE: Northeast Regional Agricultural Engineering Service, Publication FS-18, "Dairy Farm Heat Exchangers for Heating Water," April, 1979.

Table 2. Annual Savings with Desuperheating Heat Exchanger

Milk cooled daily (lb)	126°F water daily (gallons)	Annual savings	
		Electricity (kwh)	L.P. gas (gallons)
1,000	42	2,775	136
2,000	84	5,550	272
3,000	124	8,325	408
4,000	167	11,100	544
5,000	208	13,875	680
6,000	249	16,650	816
7,000	291	19,425	952
8,000	334	22,200	1,088

Table 3. Annual Savings with a Complete-condensing Heat Exchanger

Milk cooled daily (lb)	140°F water daily (gallons)	Annual savings	
		Electricity (kwh)	L.P. gas (gallons)
1,000	80	6,950	340
2,000	174	13,900	680
3,000	260	20,850	1,020
4,000	346	27,800	1,362
5,000	432	34,750	1,702
6,000	520	41,700	2,040
7,000	606	48,650	2,380
8,000	693	55,600	2,720

SOURCE: Northeast Regional Agricultural Engineering Service, "Dairy Farm Heat Exchangers for Heating Water," Publications FS-18, April, 1979.

Table 4. Allowable Investment in Desuperheating and Complete-condensing Heat Exchangers for Benchmark Farms

Variable	40-cow stanchion	100-cow free stall
Pounds milk/day	1,640	4,110
Annual electricity savings, desuperheater type	4,551 kwh	11,405 kwh
Maximum investment in desuperheater-type equipment, assuming 5-year payback, 10% interest, $0.06/kwh	$1,035	$2,594
Annual electricity savings, complete condensing type	11,000 kwh*	17,447 kwh*
Maximum investment in complete condensing equipment, assuming 5-year payback, 10% interest, $0.06/kwh	$2,502	$3,968

*Represents maximum energy used for water heating. Some heat recovered by the heat exchanger may have to be dumped, unless other uses are found for hot water.

The 40-cow dairy can save about $0.11 in energy costs per hundredweight of milk by installing the complete condensing heat exchanger, due to the water heating savings. However, the average 100-cow dairy would only spend about $0.07 per hundredweight heating water anyway, so we can credit only $0.07 per hundredweight of milk to the heat exchanger.

OTHER POSSIBILITIES FOR SAVING WATER HEATING ENERGY

Install a water heater insulation blanket to cut down on heat losses. A savings of up to 1,470 kwh per year is possible on a standard water heater. Also, use a setback thermostat on the water heater so the highest temperatures are maintained only during milking and washing times. Additionally, use cold water to sanitize the pipeline and for the final rinse. And be sure to install check valves in hot-water lines to prevent unintentional mixing of hot and cold water.

GRAIN DRYING

Don't dry corn below 18 percent moisture if it will be fed during the winter. Harvest at a lower moisture if later harvest will not increase the cost of harvest losses more than the energy cost savings. Switch to a more energy-efficient drying method; use the natural drying ability of the air with low temperatures and natural air drying systems. Also, consider some of the following energy requirements for different drying methods (per pound of water removed):

- High-speed batch or continuous flow (2,000 to 3,000 BTU/lb)
- Batch-drying in a bin (1,500 to 2,000 BTU/lb)
- Low-temperature drying in a bin (1,000 to 1,500 BTU/lb)

If you use a high-speed dryer, incorporate dryeration or a combination of high- and low-speed drying to improve capacity and energy efficiency.

FORAGE PRODUCTION

Avoid using a recutter screen on the forage chopper because a screen increases the chopper's power requirement by 70 to 100 percent. Sharpen knives frequently to obtain the optimum length of cut with minimum energy.

[*Support for the printing of this article was provided by the Illinois Department of Energy and Natural Resources.*]

Corn Gluten Feed for Dairy Cattle

Michael F. Hutjens, Scott G. Bidner, and Jerry C. Weigel

Corn gluten feed is a coproduct of the corn wet-milling industry. Shelled corn is first cleaned to remove any foreign material and to prepare it for milling and the separation process. Then, it is soaked in water and sulfur dioxide, which swells the kernels. In the soaking process (steeping), essential nutrients are absorbed by the water (steep liquor). When the soaking (or steeping) is complete, the steep liquor is drawn off and concentrated. During the subsequent wet-milling process, the corn germ is separated from the kernel. The germ is processed to remove the oil. After the germ has been removed, the remaining kernel portion, which contains the bran (exterior portion or hull of the kernel), gluten, and starch, is screened and the bran is removed. Then, the bran (or fiber) is mixed with the steep liquor and sold as either dry corn gluten feed (DCGF) or wet corn gluten feed (WCGF). There are approximately 12 to 13 pounds of dry gluten feed per bushel of corn that is processed.

RESEARCH RESULTS

The nutrient profiles of both WCGF and DCGF are shown in Table 1. Research conducted at the University of Guelph, in Canada, and the University of Illinois have demonstrated that either wet or dry corn gluten feed could be used at levels up to 25 to 30 percent of the total dry matter intake (Table 2). The results of this trial indicate that dry matter intake and milk production were depressed on the diets containing 30 and 40 percent WCGF. In the Canadian trial, both WCGF and DCGF increased the fat test (Table 3). Dairy heifers consuming WCGF showed higher average daily gains, feed efficiency, and nutrient digestibility than heifers consuming alfalfa haylage (Table 4).

Table 1. Nutrient Composition of Corn Gluten Feeds Expressed on a 100 Percent Dry Matter Basis

Type of nutrient	Wet corn gluten feed	Dry corn gluten feed
	percent	
Dry matter	43.0	90.0
Crude protein	21.0	21.0
Crude fiber	8.4	8.4
TDN	87.0	77.0
Fat	3.6	3.3
Ash	7.2	7.2
Calcium	0.1	0.1
Phosphorus	1.0	1.0
Magnesium	0.5	0.5
Potassium	1.6	1.5
Sulfur	0.4	0.3
	parts per million	
Iron	165.0	165.0
Zinc	114.4	114.4
Copper	6.0	6.0
Manganese	26.4	26.4

SOURCE: Cooperative Extension Service, *Illinois-Iowa Dairy Guide* No. 208, 1984.

Table 2. Effect of Various Levels of Wet Corn Gluten Feed (WCGF) on Milk Production

	Percent of WCGF in diet			
	0	20	30	40
Dry matter intake, lb/day	52.7	51.3	48.9	47.3
Milk, lb/day	67.1	65.7	61.7	61.9
Milk fat, %	2.9	3.0	3.2	3.2
Milk protein, %	3.2	3.1	3.1	3.1
Ration dry matter, %	64.2	52.7	49.7	46.9
WCGF, lb DM/day	...	10.3	14.7	18.9

SOURCE: *Journal of Dairy Science*, 67:1214, 1984.

Table 3. Comparison of Wet (WCGF) and Dry Corn Gluten Feed (DCGF)

	Control	26 percent WCGF	26 percent DCGF
Dry matter intake, lb/day ..	37.8	35.9	42.7
Milk, lb/day	57.2	53.5	59.0
4% FCM, lb/day	48.4	49.9	53.5
Milk fat, %	3.0	3.6	3.5
Milk protein, %	3.2	3.2	3.3

SOURCE: *Journal of Dairy Science*, 66:Supplement 1, Abstract 71, 1983.

Table 4. Dry Matter Intake and Growth Data for Heifers Fed Alfalfa Haylage or Wet Corn Gluten Feed

Measure	Alfalfa haylage	Wet corn gluten feed
Dry matter intake (lb/day)	18.7	18.5
Average daily gain (lb/day)	1.0	2.4
Increase in hearth girth (cm)*	8.3	19.1
Increase in height at withers (cm)*	4.2	6.6
Increase in body length (cm)*	6.6	9.1

*Change over 83-day test period.
SOURCE: *Journal of Dairy Science*, 67:1976, 1984.

MANAGEMENT OF DCGF

A conservative recommendation is 10 to 12 pounds per cow per day. Along with forages and minerals, this level can support 40 to 60 pounds of milk. People have successfully fed higher levels—up to 75 to 100 percent of the grain mix. One major midwest feed company recommends 30 to 40 percent corn gluten feed in the grain mix. At first, palatability can be a problem due to to odor and physical form. At high levels, protein quality may be limited because of low levels of lysine. Research at the University of Wisconsin and field observations in Illinois revealed lower production among high-producing cows that were fed only corn by-products.

Dairy farmers reported, when feeding pelleted DCGF, that less bridging occurred in gravity feeders and that cows ate the feed more readily. Pellets measure 1/4 to 5/8 inch

in diameter. Hardness varies depending upon the plant that produces the pellets. Since pellets are denser, they may be cost effective when transporting corn gluten feed long distances.

Both WCGF and DCGF have been performing better than expected. The following reasons may account for positive field and research observations:

- Since most of the starch has been removed, a higher rumen pH (less acidity) occurs, and grain overloading is less likely.
- Extra protein and phosphorus are fed, since corn gluten feed is relatively high in both. Reproductive performance has been good.
- The fiber is highly digestible since it is low in acid detergent fiber (ADF) while being high in neutral detergent fiber (NDF). The extraction process does not remove all of the starch.
- The fat test may improve since fiber levels are higher while energy values remain optimal.

When using either WCGF or DCGF, the dairy manager needs to be aware of several factors in order to make sure the product is utilized effectively:

- Be sure the mineral balance is checked. Corn gluten feed is low in calcium and may require the addition of 3 to 4 ounces of limestone or a 5 to 1 (calcium to phosphorus) commercial mineral.
- Watch phosphorus levels, especially if corn gluten feed is fed to dry cows. In order to minimize milk fever, avoid levels of more than 40 grams of phosphorus per day to dry cows.
- Have all rations reformulated for the effective use of all nutrients available in corn gluten feed.
- Light-colored DCGF is more desirable than the dark colored product, which may have been subject to heat damage during drying. As more steep water is added, the WCGF will become darker in color.

MANAGEMENT OF WCGF

Limit the level of wet gluten to 25 percent of the milk cow's total ration dry matter or 25 to 30 pounds per day. This substitution will replace all the grain for growing heifers and low producers. For the best results, this wet material should be placed in a sealed structure to reduce spoilage; when stored in an open pile for a few warm days, mold growth develops and spoilage becomes rapid. Good results have been obtained by mixing WCGF with other feedstuffs and blowing the mixture into a silo. Attempts to blow wet corn gluten feed, alone, caused blower pipes to plug up. Adding 10 percent corn, haylage, or alternative feed will keep the blower pipe clear. Packing the material intc silo bags is an excellent means of storing and maintaining the quality of the feed. Mixing corn silage (one part on a wet base) with WCGF (one part) results in a total mix ration that is high in energy and contains 15 percent crude protein on a dry matter basis. A mixture of two parts haylage (40 percent dry matter) and one part WCGF results in a feed containing 68 percent total digestible nutrients (TDN) and 18 percent crude protein on a dry matter basis. Since the material will pack tightly, check to be sure that your storage unit can handle the extra pressure and that your unloader will function. The material undergoes little or no fermentation because of the relatively low pH (4.3) of the feed at the time of delivery. The texture of the wet product is similar to oatmeal, which restricts flow and handling aspects.

ECONOMICS OF GLUTEN FEED

Two methods can be used to determine the value of DCGF. One calculation was developed at the University of Illinois using the guideline that corn gluten feed is equal to a mixture of 75 percent shelled corn and 25 percent soybean meal:

- 0.75 (75 percent) times 4.6 cents (value of 1 pound of corn) equals 3.45 cents.
- 0.25 (25 percent) times 7.5 cents (value of 1 pound of soybean meal) equals 1.87 cents.
- 3.45 cents plus 1.87 cents equals 5.32 cents per pound of DCGF.
- 5.32 cents times 2,000 pounds equals $106 per ton of corn gluten feed.

A second method for determining the value of DCGF uses Morrison's feed constants as shown below:

- Energy value equals 0.456 (constant) times 4.6 cents (value of one pound of corn) equals 0.021 cent.
- Protein value equals .434 (constant) times 7.5 cents (value of one pound of soybean meal) equals 0.032 cent.
- 0.021 cent plus 0.032 cent equals 0.053 cent per pound of corn gluten feed.
- 0.053 times 2,000 pounds equals $106 per ton of corn gluten feed.

If you can buy corn gluten feed and deliver it to the farm for less than $106 per ton, you'll receive a better buy than shelled corn priced at $2.60 per bushel (4.6 cents per pound) and soybean meal at $150 per ton.

WCGF can be priced in a similar method, but adjusted for the higher moisture level. This calculation is based upon the University of Illinois method:

- 0.75 (75 percent) times 4.6 cents (value of one pound of corn) equals 3.45 cents.
- 0.25 (25 percent) times 7.5 cents (value of one pound of soybean meal) equals 1.87 cents.
- 3.45 cents plus 1.87 cents equals 5.32 cents per pound of corn gluten.

  5.32 cents times 900 pounds (810 pounds of dry matter) equals $43 per ton of corn gluten feed. One guideline is that wet corn gluten feed is worth half the price of dry corn gluten feed delivered to the farm.

Wheat-Vetch Mixtures for Dairy Cattle Forage

Kenneth J. Moore and Edwin H. Jaster

Winter wheat, either grown alone or with a winter annual legume such as hairy vetch, can provide an excellent source of forage during the early summer months when other feeds are in short supply. In most cases, the crop is removed for forage by the middle of June, providing an opportunity for a second crop of either forage or grain. Growing wheat in a mixture with a legume has the advantages of improving the protein concentration in the forage and reducing the nitrogen fertilizer requirements of the crop. Growing winter annuals for forage also provides vegetative cover during the winter months, an important consideration for many Illinois soils.

Research was initiated in the fall of 1983 to determine the effect of different vetch seeding rates on the yield and quality of wheat-vetch harvested for forage at different stages of maturity. Wheat was planted alone (90 pounds per acre) or in combination with hairy vetch seeded at rates of 22, 44, or 66 pounds per acre. Forage was harvested when wheat was in the boot stage, at the flower stage, or in the milk stage (Table 1).

For wheat-vetch mixtures grown during the 1983-84 growing season, little effect was observed regarding the vetch seeding rate on yield for the first two harvest dates. However, at the milk stage, yield was decreased as the vetch seeding rate was increased. The yield reductions averaged 7, 21, and 28 percent for the three seeding rates. Additionally, increasing the vetch seeding rate caused an increase in concentrations of protein and digestible dry matter at all harvest dates.

Wheat-vetch mixtures harvested at the milk stage exhibited reduced dry matter yield (4.1 versus 2.4 tons per acre). However, digestible dry matter yield was similar (2.1 versus 1.8 tons per acre). Losses in protein quality normally associated with delayed harvesting were offset by additions of vetch to wheat. Adding vetch to wheat at a rate of 22 pounds per acre increased the protein content of forage at harvest (milk stage) from 8.6 to 11.0 percent.

Table 1. Yield and Composition of Wheat Forage Seeded with Vetch at Different Rates and Harvested at Three Stages of Maturity

Growth stage	Vetch seeding rate (lb/acre)	Dry matter yield (tons/acre)	In vitro dry matter digestibility (%)	Digestible dry matter yield (tons/acre)	Crude protein (%)
Boot	0	2.2	64.0	1.4	14.3
	22	2.0	65.7	1.3	16.8
	44	2.4	67.8	1.6	17.6
	66	2.2	69.7	1.5	18.4
Flower	0	3.0	56.6	1.7	10.1
	22	2.6	57.6	1.5	14.1
	44	2.7	60.2	1.6	14.7
	66	2.5	61.8	1.5	15.7
Milk	0	4.1	53.0	2.1	8.6
	22	3.8	55.1	2.1	11.0
	44	3.2	57.3	1.8	13.3
	66	2.9	62.9	1.8	14.0

In summary, growing winter wheat in a mixture with hairy vetch produces a higher quality forage than wheat grown alone. With good harvest management, improved quality can be obtained with little loss in yield. Experiments have been initiated to evaluate the feeding of wheat-vetch mixtures to dairy cattle.

Fine Tuning Grain Levels

Mark G. Cameron, Sidney L. Spahr, and Michael F. Hutjens

Dairy producers must continue to minimize feed costs while optimizing milk yield. Since forages typically are the most economical source of nutrients, maximizing forage intake will result in the highest income over feed costs. In a series of simulations using the Illini Ration Balancer computer program, two levels of corn silage and haylage, shelled corn (energy source), and soybean meal (protein source) were calculated. The feed quality is summarized in Table 1.

Table 1. Feed Quality Used in Computer Simulations

Feed	Dry matter (%)	Crude protein (%)	Net energy (Mcal/lb)	ADF (%)	Calcium (%)	Phosphorus (%)
Shelled corn	86	10	.92	3	.02	.31
Soybean meal	90	49	.90	10	.36	.75
Haylage	60	18	.60	36	1.20	.20
Corn silage	35	8.5	.65	31	.31	.19

Standard values used in the simulations (unless changed as a test variable) were 1,400 pound body weight per cow, 60 pounds of milk, 3.5 percent milk fat, 120 days in milk, third lactation, and an average degree of fleshing (body condition code 3). The ranges of simulated values were 30 to 90 pounds of milk; 900 to 1,600 pounds of body weight; and milk fat from 2.5 to 5 percent. Additional ranges were 20 (7.5 percent milk production lead factor), 40 (5.0 percent milk production lead factor), and 120 (no lead factor) days in milk. Five body condition codes were assigned: 1 (thin and gaining one pound of weight per day); 2 (moderately thin and gaining 1/2 pound per day); 3 (average and no change in weight); 4 (moderately heavy and losing 1/2 pound per day); and 5 (heavy and losing one pound per day).

Three lactation numbers also were used: lactation number 1 (20 percent increase in maintenance for growth); number 2 (10 percent increase in maintenance for growth); and number 3 (mature size).

The effects of milk yield, fat test, body weight, age (growth), stage of lactation (lead factor), and body condition change are illustrated in Tables 2 and 3. Two different forage types were used: 75 percent corn silage-25 percent haylage and 75 percent alfalfa-25 percent corn silage on a dry matter basis.

Table 2. Computer Simulation of 25 Percent Corn Silage and 75 Percent Alfalfa Haylage Ration

Standard values	Shelled corn (lb)	Soybean meal (lb)	Dry matter intake (lb)	Forage as-fed: Corn silage (lb)	Forage as-fed: Alfalfa haylage (lb)	Acid detergent fiber (%)	Forage (%)
Milk production (lb)							
30	1.0	0.0	31.7	20.76	36.38	33.7	97.3
50	9.2	0.0	38.7	20.76	36.38	28.1	79.7
70	18.9	2.9	44.2	17.13	30.02	21.5	57.4
90	25.7	5.9	51.2	16.04	28.11	18.4	46.4
Body weight (lb)							
900	17.9	4.1	34.3	10.31	18.06	17.8	44.6
1,100	17.5	3.3	36.7	12.60	22.07	19.6	50.9
1,300	16.2	2.1	39.3	15.86	27.79	22.2	59.9
1,500	12.3	0.0	43.6	22.25	38.99	26.9	75.7
Milk fat (%)							
2.5	11.2	0.0	39.1	19.89	34.85	26.8	75.5
3.0	12.8	0.3	40.3	19.56	34.28	25.8	72.0
3.5	14.0	0.8	41.6	19.42	34.03	25.0	69.4
4.0	15.2	1.3	42.9	19.35	33.90	24.3	66.9
4.5	16.7	1.9	44.2	18.95	33.20	23.3	63.6
5.0	18.3	2.5	45.3	18.40	32.24	22.4	60.4
Lactation number							
1	19.5	2.0	42.3	16.04	28.11	21.0	56.2
2	17.3	1.6	41.7	17.06	29.89	22.4	60.8
3	14.0	0.8	41.6	19.42	34.03	25.0	69.4
Stage of lactation (days)							
20	18.2	2.6	41.7	16.04	28.11	21.4	57.0
40	17.2	2.1	41.5	16.81	29.45	22.0	60.0
120	14.0	0.8	41.6	19.42	34.03	25.0	69.4
Condition code							
1	19.2	2.7	42.7	16.04	28.11	21.0	55.7
2	17.7	2.2	41.6	16.44	28.81	21.8	58.7
3	14.0	0.8	41.6	19.42	34.03	25.0	69.4
4	11.5	0.2	40.9	20.76	36.38	26.8	75.4
5	10.2	0.1	39.7	20.76	36.38	27.5	77.6

Table 3. Computer Simulation of 75 Percent Corn Silage and 25 Percent Alfalfa Haylage Ration

Standard values	Shelled corn (lb)	Soybean meal (lb)	Dry matter intake (lb)	Forage as-fed Corn silage (lb)	Alfalfa haylage (lb)	Acid detergent fiber (%)	Forage (%)
Milk production (lb)							
30	0.0	0.6	31.1	62.10	12.02	31.9	98.5
50	5.6	3.2	38.3	62.10	12.02	26.9	80.0
70	15.4	6.3	44.1	51.14	9.90	20.5	57.1
90	21.3	8.9	51.5	51.14	9.90	18.3	48.9
Body weight (lb)							
900	15.0	6.1	34.5	32.89	6.37	17.8	46.9
1,100	14.0	5.7	36.9	40.18	7.78	19.6	53.6
1,300	12.9	5.3	39.2	47.46	9.18	21.2	59.6
1,500	7.7	4.3	43.3	66.54	12.88	25.7	75.8
Milk fat (%)							
2.5	6.6	3.6	39.0	61.10	11.83	26.1	77.2
3.0	8.2	4.1	40.3	59.84	11.58	25.0	73.4
3.5	9.4	4.6	41.7	59.68	11.55	24.3	70.6
4.0	10.9	5.1	42.8	58.42	11.31	23.4	67.3
4.5	12.2	5.6	44.1	58.09	11.24	22.7	64.9
5.0	13.8	6.2	45.4	56.83	10.99	21.8	61.6
Lactation number							
1	15.0	5.1	42.6	51.14	9.90	21.0	59.1
2	13.7	5.1	41.5	51.14	9.90	21.5	60.7
3	9.4	4.6	41.7	51.68	11.55	24.3	70.6
Stage of lactation (days)							
20	13.7	5.7	42.1	51.14	9.90	21.3	59.8
40	13.2	5.5	41.5	51.14	9.90	21.5	60.7
120	9.4	4.6	41.7	59.68	11.55	24.3	70.6
Condition code							
1	14.8	5.7	43.0	51.14	9.90	20.9	58.6
2	13.6	5.4	41.7	51.14	9.90	21.4	60.4
3	9.4	4.6	41.7	59.68	11.55	24.3	70.6
4	7.2	4.4	40.8	62.10	12.02	25.6	75.1
5	5.9	4.3	39.5	62.10	12.02	26.3	77.6

Malt Sprouts as a Protein Supplement for Ruminants

Peter S. Erickson, Michael R. Murphy, and Carl L. Davis

Malt sprouts are rootlets, sprouts, and some hulls removed from malted barley. Although they have been used extensively for years in livestock feeding, few data are available regarding utilization of malt sprouts by ruminants. The solubility of nitrogen, degradation rate of insoluble nitrogen, and potential for a significant portion of nitrogen to escape ruminal breakdown are important factors affecting the value of malt sprouts as a source of supplemental protein for livestock. Our objectives were to compare nitrogen solubility and ruminal degradation of pelleted malt sprouts, pelleted corn gluten feed, and soybean meal.

Two ruminally cannulated Holstein steers were fed a diet consisting of 45 percent pelleted malt sprouts, 40 percent corn silage, 10.87 percent ground shelled corn, 3 percent soybean meal, 1 percent trace mineralized salt, 0.1 percent limestone, and 0.03 percent vitamin A and D supplement on a dry matter basis. Two more steers received a similar diet with 45 percent pelleted corn gluten feed substituted for malt sprouts. After a fourteen day adjustment period, polyester bags (7 by 11 centimeters) filled with about 1 gram of ground malt sprouts or ground corn gluten feed were placed in the rumen of the steers that were fed the two diets. Two bags were removed after 1, 2, 3, 4, 6, 8, 10, 12, 16, and 24 hours of incubation and then washed and dried to determine dry matter disappearance. The bags were analyzed for nitrogen in order to estimate nitrogen disappearance. For comparison, bags containing soybean meal were included with each of the other feedstuffs and removed 2, 4, 8, and 24 hours after placement in the rumen.

Chemical analyses of each protein supplement are shown in Table 1. Nitrogen content, solubility, unavailable nitrogen, and rates of dry matter and degradable nitrogen disappearance are shown in Table 2. Dry matter and degradable nitrogen disappearance rates were lowest for malt sprouts. Data suggest that more supplement dry matter and crude protein would escape ruminal fermentation and be available for digestion in the abomasum and small intestine of the cattle which were fed malt sprouts as compared with those cattle which received the other feeds, provided rates of passage from the rumen are similar.

Further research is needed to examine the digestibility and feeding limits of this byproduct.

Table 1. Chemical Composition of Protein Supplements

Feed	Dry matter (%)	Crude protein	Ether extract	Acid detergent fiber	Neutral detergent fiber	Ash
		percent of dry matter				
Malt sprouts	92.5	20.9	3.2	24.4	50.2	7.9
Corn gluten feed	86.7	21.6	10.9[a]	14.8	39.3	9.5
Soybean meal	88.3	51.0	1.0	6.5	7.4	8.6

[a]This value is atypical compared with other values from our lab (4.9 percent). Corn Refiners, Inc., reports values of 1.4 to 3.5 with a mean of 2.5 percent fat.

Table 2. Nitrogen (N) Fractions, Dry Matter (DM), and Nitrogen Disappearance Rates of Protein Supplements

Feed	N-content (% DM)	N-solubility (% of total N)	Unavailable N[a] (% of total N)	Insol/avail N[b] (% of total N)	Rates of disappearance (%/h)[c]	
					Dry matter	Insol/avail N
Mail sprouts	3.3	38.1	3.5	58.4	2.5	4.5
Corn gluten feed	3.4	45.8	10.0[d]	44.2	4.4	7.4
Soybean meal	8.2	16.0	6.9	77.0	11.5	9.0

[a]Nitrogen bound to the acid detergent fiber fraction of the feed, termed acid detergent insoluble nitrogen (ADIN), is unavailable to the animal.
[b]Insoluable/available N is total nitrogen minus the sum of soluble and unavailable nitrogen.
[c]Determined by rumen incubation of the feeds in dacron bags for periods of time ranging from 1 to 24 hours.
[d]The pelleted corn gluten feed was very dark in color and evidently had been subjected to excess heat. Again, a quality control problem is suggested.

Digestion and Utilization of Sweet and Acidified Milk Replacers by Young Dairy Calves

Steven T. Woodford, Michael R. Murphy, and Carl L. Davis

A profitable dairy herd is contingent upon the successful rearing of vigorous, healthy calves as herd replacements. The most expensive phase of calf rearing is during the liquid feeding phase. Thus, both minimizing labor and maximizing nutrient utilization are extremely important.

From a nutritional standpoint, providing milk replacer on a free-choice basis may be more beneficial compared with the traditional method of once or twice daily restricted feedings: the free-choice basis more closely mimics nursing from the dam. Small, frequent meals could enhance digestion by not flooding the digestive tract of the calf. Acidification of a milk replacer not only prevents spoilage but also should help maintain a lower pH in the calf's digestive tract, which could potentially enhance nutrient digestion. These possible benefits should be weighed against potential problems of product acceptability, early excessive gain, increased purchases of replacer powder, and a more difficult weaning period.

The objective of this study was to compare nutrient utilization, feeding pattern, and growth when calves were fed either sweet replacer twice daily or acidified replacer free choice. Ten Holstein bull calves were abomasally cannulated within one to two weeks of birth. Upon recovery from surgery, calves were fed either sweet milk replacer twice daily and restricted to 10 percent of body weight per day (via nipple pails), or acidified milk replacer free choice (via a nipple). Fresh acidified replacer was given every three days to each calf. Both replacers were 20 to 21 percent crude protein (all whey proteins), 14 to 15 percent fat, and reconstituted to 13 percent dry matter. The pH of sweet replacer was 6.4, and the pH of acidified replacer was 5.2. Water was available at all times, and calves were housed in elevated metal crates.

During the second and fourth weeks of the trial, diet digestibility was determined by total collection of feces and urine. Abomasal samples from all calves were taken every half-hour for 12 hours and hourly for the next 12 hours. Consumption of replacer between these times was recorded for the calves that were fed acidified replacer. These data were used to determine the feeding pattern.

Calves that were offered the acidified milk replacer free choice consumed twice as much fluid and dry matter as restricted fed calves (Table 1). The high intakes resulted in both a substantially increased weight gain and a decreased feed-to-gain ratio. The latter effect was due to a greater proportion of the energy intake going to weight gain instead of maintenance in the calves that were fed acidified replacer.

Nutrient digestibilities (Table 2) showed no difference in the dry matter, crude protein, and fat digestibility of the two replacers. Calves fed the acidified product were able to digest large quantities of replacer as efficiently as calves fed restricted amounts. In addition, no difference was found in the utilization of absorbed nitrogen (Table 2).

The number of individual feedings in 24 hours ranged between 9 and 29 for the calves that were fed the acidified replacer. Fecal pH was lower for these calves, indicating that the digestive tract tended to be more acidic. Urine output was 50 percent greater for calves consuming large amounts of acidified replacer, which could lead to more frequent bedding changes.

The results from this study suggest that calves consuming large quantities of acidified replacer utilize the nutrients they consume as effectively as those calves fed restricted amounts of sweet replacer. Labor savings are also possible because replacer can be reconstituted in larger batches every two or three days.

Table 1. Feed Intake, Weight Gain, and Efficiency of Gain in Calves Fed Sweet or Acidified Replacer

	Treatment	
Measure	Sweet replacer	Acidified replacer
Intake, lb/day		
Replacer	11.90	22.10
Dry matter (DM)	1.55	2.88
Average daily gain, lb/day	0.47	1.35
Feed efficiency, lb DM/lb gain	6.20	4.76

Table 2. Dry Matter, Crude Protein, and Fat Digestibility and Retention of Nitrogen

	Treatment	
Measure	Sweet replacer	Acidified replacer
Nutrient digestibility		
Dry matter, %	94.4	95.8
Fat, %	100.0	100.0
Crude protein, %	88.4	87.1
Nitrogen retained as percentage of that absorbed	60.9	64.1

Supplemental Branched Chain Volatile Fatty Acids for Lactating Dairy Cows

Tim H. Klusmeyer, Jimmy H. Clark, John L. Vicini, Michael R. Murphy, and George C. Fahey, Jr.

Fermentation of protein and carbohydrate in the rumen results in the formation of short chain fatty acids including branched chain (isobutyric, 2-methyl butyric, and isovaleric) as well as the straight chain (valeric). Fiber-digesting bacteria present in the rumen require these fatty acids and ammonia for their growth. The addition of these acids to poor quality forage diets (often low in preformed protein content) fed to growing ruminant animals has increased dry matter intake, fiber and dry matter digestibility, and nitrogen retention. The improved responses may be at least partly attributed to an increased activity of fiber digesting bacteria in the rumen. Recently, the addition of these fatty acids to diets of lactating dairy cows increased milk production by 2 to 6 pounds per cow per day. Because such diets contained adequate amounts of protein and fermentable energy, it is not likely that the improved milk production was caused by increased fiber digestibility.

Eight ruminal-fistulated Holstein cows, averaging 77 days postpartum, were used in a 4 by 4 Latin square arrangement with 28-day periods to determine the effect of supplementing fatty acids on lactational performance and their mechanisms and sites of action. The first 14 days of each period were used for the adjustment of cows to treatments and were followed by 14 days of data collection. All cows were fed *ad libitum* a complete mixed ration of 55 percent corn silage and 45 percent concentrate on a dry matter basis that was top-dressed with four pounds of premix per cow, daily. The concentrate consisted of 51.65 percent ground shelled corn, 43.10 percent soybean meal (48 percent crude protein), 2.60 percent limestone, 0.85 percent dicalcium phosphate, 0.50 percent sodium sulfate, 1 percent trace mineral salt, 0.25 percent magnesium oxide, and 0.05 percent vitamin A and D supplement. The premix consisted of 10 percent dry molasses and 90 percent ground shelled corn either with or without fatty acids. The four treatments were control; fatty acids fed in the ration; ruminally infused fatty acids; and abomasally infused fatty acids. Except for those receiving the control treatment, each cow was supplemented with 4 ounces of fatty acids.

Dry matter intake and milk production were recorded daily. Milk composition was determined from milk samples taken twice daily from days 15 to 28 of each period. Ruminal fluid samples were collected hourly for 24 hours on day 26 of each period. These samples were assayed for ammonia, pH, and volatile fatty acids. Polyester bags that contained the complete mixed ration were placed in the rumen and removed at frequent intervals to determine the rate and extent of dry matter, nitrogen, and cellulose disappearance. Apparent digestibilities of the experimental diets were determined by using chromic oxide as a marker. Blood plasma was collected hourly for 24 hours on day 27 of each period through the use of an indwelling jugular catheter. Plasma samples were assayed for glucose, free fatty acids, and growth hormone.

Results from this trial are shown in Table 1. Dry matter intake and efficiency of dry matter utilized for 4 percent fat-corrected milk production were not significantly different between cows receiving control and fatty acid fed or infused treatments. Feeding or infusing fatty acids did not affect milk yield, 4 percent fat-corrected milk yield, or milk composition. Ammonia concentrations, pH, and molar percentages of volatile fatty acids in ruminal fluid were not altered significantly by fatty acid supplementation. Also, the rate and extent of dry matter, cellulose, and crude protein disappearance from polyester bags placed in the rumen were not different among treatments. Apparent digestibility of the dietary components and the total digestibile nutrients (TDN) content of the diets were not altered significantly by fatty acid supplementation. Additionally, average daily concentrations of glucose, free fatty acids, and growth hormones in plasma were not affected significantly compared with cows fed the control ration.

The facts that the above parameters were not altered and that ruminal microbes can produce branched chain and straight chain fatty acids from protein and carbohydrate sources suggest that these cows received adequate amounts of isobutyric, isovaleric, 2-methyl butyric, and valeric acids from the nonsupplemented control ration for optimal ruminal fermentation and maximum milk production. The mechanisms by which these fatty acids have increased milk production in previous trials is not known.

Table 1. *Effects of Fatty Acid Supplementation on Dry Matter Intake, Milk Production, Milk Composition, Ruminal Characteristics, Apparent Digestibility of Diets, and Plasma Metabolites*

Item	Control	Fatty acids in feed	Ruminally infused fatty acids	Abomasally infused fatty acids
Dry matter intake, lb/day	48.7	49.6	48.7	48.9
Milk, lb/day	61.7	64.1	62.3	64.3
4% FCM, lb/day	56.4	58.4	57.3	59.7
lb 4% FCM/lb dry matter intake	1.16	1.18	1.17	1.22
Milk composition, %				
Protein	3.52	3.43	3.52	3.43
Fat	3.56	3.47	3.51	3.57
Solids-not-fat	8.86	8.82	8.42	8.40
Ruminal measurements				
Ammonia, mg/dl	12.8	13.2	12.8	12.7
pH	5.87	5.84	5.84	5.85
Volatile fatty acids, mM	129.2	128.5	129.3	131.5
Volatile fatty acids, molar %				
Acetic	56.81	56.83	56.32	56.53
Propionic	27.21	27.55	17.65	27.88
Butyric	11.83	11.38	11.49	11.53
Isovaleric + 2-methylbutyric	2.23	2.29	2.45	2.20
Valeric	1.91	1.94	2.09	1.85
Disappearance from polyester bags after 24 hours, %				
Dry matter	70.22	70.82	70.84	70.41
Cellulose	25.18	27.86	25.63	23.99
Crude protein	79.89	79.32	80.70	82.37
Apparent digestibility, %				
Dry matter	74.6	75.0	75.8	74.5
Crude protein	75.1	76.0	76.6	75.0
Ether extract	84.9	85.3	85.3	86.5
Acid detergent fiber	48.8	49.6	50.7	48.0
Nitrogen-free extract	83.2	83.1	84.3	83.5
Neutral detergent fiber	51.8	52.0	52.7	50.7
Hemicellulose	55.3	55.3	55.1	54.1
Cellulose	54.7	54.6	56.1	54.8
TDN, %	75.6	75.7	76.7	75.7
Plasma metabolites				
Glucose, mg/dl	63	64	63	65
Free fatty acids, μEq/liter	205	200	204	207
Plasma growth hormone, ng/ml	7.34	6.59	7.25	7.59

Effect of Altering the Sequence of Feeding Forage and Concentrate on Ruminal Fermentation and Dairy Cattle Performance

Daniel G. Giacomini, Jimmy H. Clark, and John L. Vincini

Lactating multiparous Holstein cows just past peak milk production were used in three trials to evaluate the effect of varying the sequence of feeding concentrates and forages on dry matter intake, ruminal fermentation, and milk yield, as well as milk composition, efficiency of feed utilization, and change in body weight. A Latin square design was used in each trial. The length of each period in the Latin squares was 28 days: fourteen days to adjust the cows to the feeding regimen and 14 days for data collection. The basic diets in trials 1 and 2 consisted of 60 percent concentrate and 40 percent corn silage (dry matter basis), and in trial 3 the basic diet was 60 percent concentrate and 40 percent alfalfa-brome grass hay (dry matter basis). Cows were milked twice daily at 5 a.m. and 3:30 p.m. and

llowed to exercise from 2 p.m. to 3:30 p.m. In trials 2 and 3, ruminal fluid was collected rom rumen-fistulated cows at hourly intervals on day 27 of each period in the Latin square. he ruminal fluid was tested for pH, volatile fatty acid (VFA), and ammonia determinations.

RIAL DESCRIPTIONS

RIAL 1

Eight cows were fed concentrate and corn silage. The treatments consisted of total ixed ration (TMR); total ration unmixed, forage, and concentrate offered at the same time TRU); concentrate fed four hours before forage (C:F); and concentrate fed four hours after orage (F:C).

RIAL 2

Three rumen-fistulated cows were fed concentrate and corn silage. The treatments were MR, C:F, and F:C.

RIAL 3

Long hay replaced corn silage. Twelve cows were used, and three of the cows were suricallly fitted with ruminal fistulae. The treatments were TRU, C:F, and F:C.

The cows' dry matter intakes did not differ among the treatments during the three rials (Table 1). Feeding a TMR that contained corn silage as the forage did not alter milk roduction or 4 percent fat corrected milk (FCM) production compared to the other feeding egimens (Trials 1 and 2). Feeding corn silage in the TRU decreased both milk and 4 percent CM production in comparision with feeding C:F or F:C (Trial 1). Similarly, feeding hay in he TRU decreased 4 percent FCM when compared with C:F or F:C (Trial 3). The sequence in hich feeds were offered (C:F or F:C) did not alter milk or 4 percent FCM production in any f the trials. Both milk fat percentage and yield were low and did not differ among any of he feeding regimens (Table 1). The high molar concentration of propionate and the low molar atio of acetate to propionate (Table 2) observed in these trials has been associated preiously with low milk fat percentages and yields. Milk protein percentage was not affected y the feeding regimens. Additionally, the milk solids-not-fat (SNF) percentage and yield ere lower for C:F in comparison with F:C during both trials when cows were fed corn silage s the forage (Table 1). The TMR also decreased SNF percent in trial 2.

Feeding both TMR and TRU resulted in a similar efficiency of feed utilization in the roduction of 4 percent FCM. Feeding either TMR or TRU resulted in a lower efficiency of eed utilization than feeding C:F and F:C. However, the only significant differences ccurred when hay was fed (Trial 3) as forage. Frequency of feeding may have contributed to part of the improvement because cows fed C:F or F:C were offered feed four times daily as ompared with only twice daily for cows fed TMR and TRU. Feed utilization was less efficient when F:C was fed than when C:F was fed, but differences were only significant when the forage was hay (Trial 3).

Mean daily ruminal fluid pH showed no difference among treatments (Table 2). Feeding TMR or TRU rather than C:F or F:C resulted in a more stable ruminal fluid pH. The greatest decline in ruminal fluid pH occurred after cows were fed concentrate, regardless of the feeding regimen. Changes in total and individual VFA concentrations from hour to hour during a 24 hour period indicate that, immediately after feeding TMR, TRU, or concentrate (either before or after forage), there was an increase in the molar concentration of VFA in ruminal fluid; a decrease in ruminal fluid pH; and an alteration in the molar concentrations of individual VFA, which resulted in a decrease in the ratio of acetate to propionate. Although the individual VFA changed after feeding, the mean daily molar concentrations of acetate, propionate, butyrate, and isovalerate in ruminal fluid were not altered by these feeding regimens (Table 2).

The best feeding regimen for optimizing milk production and composition cannot be determined from these trials; however, there were consistent changes in ruminal pH and molar concentrations of total and individual VFA after feeding that resulted in a significant change in the acetate to propionate ratio. These changes in ruminal fermentation were the result of the time at which cows consumed the rapidly fermentable carbohydrate supplied by concentrate in relation to the time cows ate forage. Molar percentages of propionate above

25 in ruminal fluid or acetate to propionate molar ratios lower than 2.2 have been shown to depress milk fat percentage. An alteration of ruminal pH, molar percentages of VFA, and acetate to propionate molar ratios caused by more frequent feeding or by changing the time or sequence in which forage and concentrate are fed to cows may help to optimize ruminal fermentation and also help to improve milk production, milk fat percentage, and efficiency of feed utilization. If a TMR is not fed, feeding forage one to two hours before or after feeding concentrate appears to be the most beneficial range of time for improving ruminal fermentation and animal performance. The optimum time to attain the best performance when feeding forage will depend upon the amount of the diet that is consumed, the composition of the diet, and the rate at which the forage is fermented in the rumen.

Table 1. Effect of Sequence of Feeding Concentrate and Forage on Lactational Performance and Ruminal Fermentation of Dairy Cows

Parameter	Total mixed ration (TMR)	Total ration unmixed (TRU)	Concentrate: forage (C:F)	Forage: concentrate (F:C)
	Trial 1			
Dry matter intake, lb/day	51.1	49.3	50.0	52.0
Milk, lb/day[a]	76.2	72.7	78.4	80.4
4% FCM, lb/day[a]	64.3	62.3	68.3	68.7
Milk fat, %	3.00	3.10	3.17	3.08
Milk protein, %	3.28	3.28	3.35	3.31
Solids-not-fat, %[b]	8.59	8.50	8.32	8.52
lb FCM/lb dry matter intake	1.25	1.25	1.36	1.32
Body wt. change, lb[c]	48.0	-9.0	-39.0	20.0
	Trial 2			
Dry matter intake, lb/day	46.7		43.8	46.0
Milk, lb/day	61.9		64.3	65.6
4% FCM, lb/day	50.7		54.4	54.6
Milk fat, %	2.85		2.95	2.99
Milk protein, %	3.35		3.36	3.45
Solids-not-fat, %[b,d]	8.24		8.47	8.77
lb FCM/lb dry matter intake	1.09		1.24	1.17
Body wt. change, lb[b,d]	11.0		3.0	47.0
	Trial 3			
Dry matter intake, lb/day		46.9	44.5	48.5
Milk, lb/day		76.0	77.8	80.4
4% FCM, lb/day[a]		57.5	60.1	62.1
Milk fat, %		2.47	2.51	2.50
Milk protein, %		3.07	3.01	3.01
Solids-not-fat, %		8.22	8.14	8.36
lb FCM/lb dry matter intake[a,e]		1.20	1.36	1.26
Body wt. change, lb[b]		14.0	14.0	53.0

[a]TRU less than C:F and F:C.
[b]C:F less than F:C.
[c]TMR greater than TRU, C:F, and F:C.
[d]TMR less than C:F and F:C.
[e]C:F greater than F:C.

Table 2. *Effect of Sequence of Feeding on Ruminal Parameters of Lactating Cows Fed a Diet Consisting of 60 Percent Concentrate and 40 Percent Forage*

Parameter	Treatments: Total mixed ration (TMR)	Total ration unmixed (TRU)	Concentrate: forage (C:F)	Forage: concentrate (F:C)
	Trial 2			
pH	5.61		5.60	5.54
VFA, mM	128.1		133.9	123.1
Acetate, mM	68.3		69.8	60.7
Propionate, mM	36.7		37.1	41.0
Butyrate, mM	17.8		20.6	14.8
Isovalerate, mM	2.3		2.8	2.4
Valerate, mM[a]	2.9		3.5	4.2
Acetate:propionate ratio[b]	1.95		2.02	1.51
Ammonia, mg/dl	10.6		12.9	7.7
	Trial 3			
pH		5.61	5.75	5.55
VFA, mM		122.8	112.8	117.9
Acetate, mM		69.6	68.4	63.9
Propionate, mM		34.4	26.5	39.2
Butyrate, mM		14.4	13.8	10.9
Isovalerate, mM		2.0	2.2	1.5
Valerate, mM		2.4	1.9	2.4
Acetate:propionate ratio[c]		2.18	2.64	1.69
Ammonia, mg/dl		11.1	11.2	6.2

[a]TMR less than C:F and F:C; and C:F less than F:C.
[b]TMR greater than C:F and F:C; and C:F greater than F:C.
[c]C:F greater than F:C.

Electronic Animal Identification--The Building Blocks for Automation

Sidney L. Spahr and Hoyle B. Puckett

Development of commercial systems for electronic identification of livestock is the major technological breakthrough that is allowing for the evolution of livestock automation. The first system appeared commercially in the U.S. about 1979. Since that time the newer units have become smaller, more reliable, cheaper, and have greater capacity for the number of animals on a single system. Some of the commercial systems now available have a capacity of 10 billion different numbers, and some of them may be programmed to have sequential numbers for a specific installation, after they leave the factory.

Industrial development of electronic identification is continuing, and several companies are working toward specific applications in livestock production. Some of the technical features of electronic identification (ID) systems are shown in Table 1. Most of the ID units worn by the cow are powered by radio frequency (rf) energy emitted from a stationary transmitter. These units are typically located at a feed dispensing stall, in a milking parlor, or at some other location where animals will be confined. When the ID unit worn by the animal becomes powered up, it transmits an electronically coded unique signal which is received by an antenna and then decoded and matched electronically with the herd name or the number of the animal wearing that specific ID tag.

In our research we have found many applications for enhancing livestock production practices. We also have found a number of features in various systems which make them better for some applications than for others. For example, some units use implants that are permanent and could be used to monitor biological changes (for example, tissue composition

Table 1. Major Electronic Animal Identification Systems

Manufacturer	Address	Battery or passive	Animal attach-ment	Range of interro-gation	Comments
All flex	Walnut Creek, CA	Passive	Ear	3 ft +	Suitable for archway ID Surface acoustical wave
BI (Boumatic, Harvestore, Zero)	Boulder, CO	Passive	Neck	6 in.	
Boumatic	Madison, WI	Passive	Neck	2-3 ft	Suitable for archway ID To be released Fall 85
Cattle Code (Westfalia, Universal)	Schiller Park, IL	Passive	Neck	6 in.	
Data Feed	Billings, MT	Battery	Neck	6 in.	Switched on by magnet
DeLaval	Kansas City, MO	Passive	Neck	12 in.	
Eureka	Slough, England	Battery	Ear	18-24 in.	Powered up by rf
Farmtronix	St. Louis, MO	Passive	Neck	6 in.	
Farm Technology .... (Mix Mill)	Bozeman, MT	Battery	Implant or Neck	6 in.	
IDI	Westminster, CO	Passive	Implant	2 in.	
IDI (Surge)	Westminister, CO	Passive	Neck	6 in.	
UIS (Pinpointer) ...	Cookville, TN	Passive	Ear	6 in.	

SOURCE: Sidney L. Spahr.

and temperature). However, most of the ID units are too large to be feasible as implants; most of the units require that the transmitter and receiving antenna be within about 6 inche of the ID unit. Implanting usually reduces the range of interrogation so that many of today's systems are not powerful enough to be used as implants.

Major improvements in the life of batteries have led some developers to design their ID units to be powered with batteries to increase the range of interrogation. This approach is useful if the user desires to attach a physiological sensor to an electronic ID unit. Examples of such units under development for livestock are temperature sensors, activity tags, and tissue composition sensors.

During the last year we installed two electronic ID systems in our milking parlor at the University of Illinois's dairy research farm. On one side of the parlor, we installed a Surge system, which identifies cows with the same ID units that are used for automatic individual feed dispensing. Readers were set up in the manger section of each stall and were positioned to be in close proximity to the neck-mounted ID unit worn by the cow when she entered. Each cow was automatically identified, and her identity was matched with electronically-measured milk yield and electrical conductance (measure of subclinical mastitis) from each quarter. Typically, about 32 of 34 animals will be identified automatically with the Surge system. If a cow fails to be identified, it is almost always because she did not get her head into the right position to allow the ID unit to be close enough to the reader (within 4 to 6 inches). This limitation has been a chronic problem with our very tall cows.

The second system we installed was the Eureka system. This ID unit is small enough to be worn as an eartag. The readers are positioned over the top of the cow, and the rf energy required to activate the units is directed down to the ear. These units have a range of about 18 inches, a feature which makes them especially attractive for ID in the milking parlor. Unfortunately a few of the units have been lost, and a few batteries in the ID unit have gone bad. However, the system looks promising for in-parlor usage. As with the Surge system, we use it to automatically record data for milk yield and electrical conductance of the milk.

The Quandry of DUMPS

Roger D. Shanks and James L. Robinson

UMP synthase is an enzyme that converts orotic acid to the pyrimidine UMP (uridine-5'-monophosphate). Because UMP is needed for the formation of nucleic acids (DNA and RNA), the enzyme is found in all cells in cattle and is essential for normal growth and development. *DUMPS* (Deficiency of UMP Synthase), an inherited condition among dairy cattle, was discovered by scientists at the University of Illinois. Two years ago, we reported that about 2 percent of Illinois Holsteins were carriers of DUMPS (each having one-half the enzyme activity of normal animals), but at the time we didn't know in which ways the animals were affected by the condition, if at all.

This paper presents an update of our research since that time. The title gives a hint about our conclusions: in fact, DUMPS does present a quandry because both positive and negative consequences may be associated with the condition in dairy cattle. It appears that carriers of DUMPS may exhibit increased milk production but at the same time may have their reproduction affected adversely.

MILK PRODUCTION

We have investigated milk production in two independent studies. In the first, milk production was analyzed in the daughters of twenty bulls known to be either normal or carriers of DUMPS. Six bulls that were carriers exhibited enzyme activity which was approximately half that of the fourteen normal bulls. Daughters of the carrier bulls averaged 730 pounds more milk production on a 305 day, 2x, mature equivalent (ME) than the daughters of the normal bulls. Because all bulls were sons or grandsons of a single male ancestor, our conclusions must be restricted to his descendants. Predicted difference milk was evaluated and a 220-pound advantage to carrier bulls was calculated, but this advantage was not statistically significant. Therefore, our conclusion was that the difference between daughters in milk production could involve a common environmental as well as genetic component.

In our second study, lactation records on 34 carrier and 1,417 normal cows were used to estimate the effect of DUMPS on milk production. Carrier cows in second or later lactations exhibited greater milk production than first-calf, carrier cows (Figure 1). Normal cows from both lactation groups were intermediate for milk production. Carrier cows in either second or later lactations and daughters of carrier bulls were associated with greater milk production than other groups.

REPRODUCTION

In our second study, we also evaluated calving interval (the number of days between subsequent calvings) and found that carrier cows in second or later lactations averaged longer calving intervals than those of first lactation, carrier heifers (Figure 1). Normal cows were intermediate for calving interval. The differences in calving interval between the groups could be responsible for a portion of the differences in milk production between the groups. Therefore, again, we conclude that observed differences in milk production were a function of environmental (calving interval management) and genetic components. Additionally, extended calving intervals are undesirable because they reduce returns by delaying births of herd replacements.

CALF MORTALITY

Theoretically, one-fourth of the matings between carrier females and carrier males will result in calves that do not have any UMP synthase and would be expected to die prematurely. To date, we have not found any such calves. From seven calves born from such matings, five were carriers of DUMPS and two were normal for UMP synthase. A ratio of two carriers to one normal calf would suggest that the expected calf with no UMP synthase does not develop to term. So, rather than calf mortality as a consequence of DUMPS, embryonic death and the associated longer calving interval may be the only undesirable effects. Embryonic death from DUMPS could be prevented by avoiding carrier-by-carrier matings.

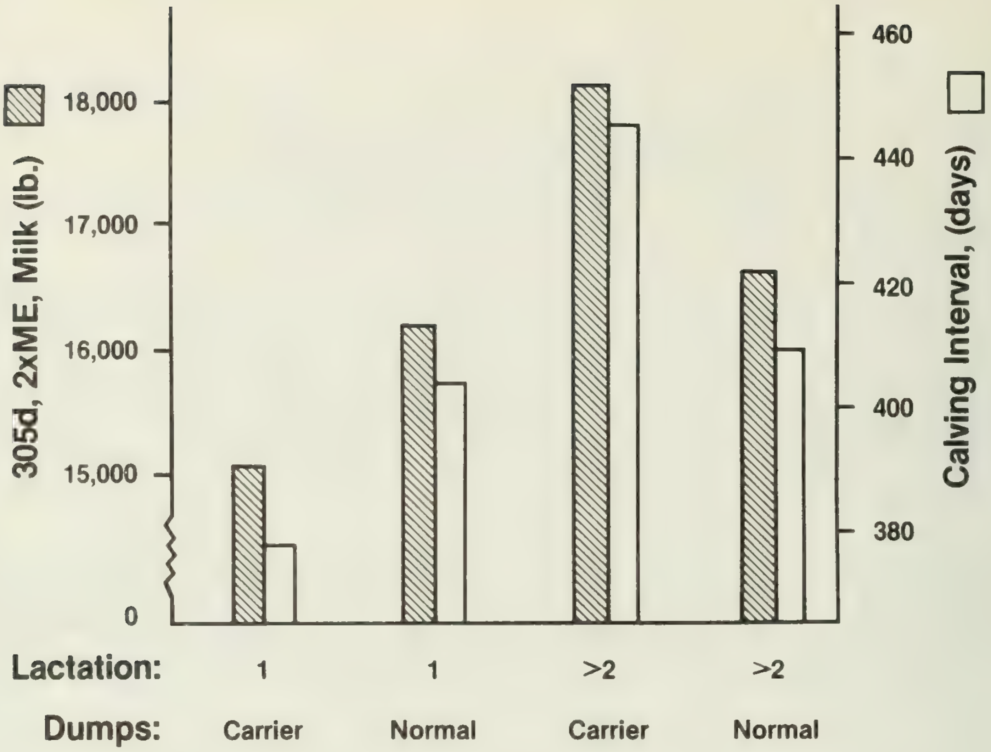


Figure 1. Association of DUMPS with milk production and calving interval.

INCIDENCE

While DUMPS involved a reduction of UMP synthase activity in all the tissues we examined, the condition is conveniently analyzed in the disintegration of red blood cells. Since this activity is affected by the age and sex of the animal, these factors must be taken into account when testing for the condition. The activity of newborns is 80 percent greater than adult values, while the activity for yearlings is 11 percent greater. The greatest decline in activity is evident in the first 100 days of life and becomes gradual thereafter. The UMP synthase activity of males is approximately 10 percent greater than that of females at all ages. On the other hand, the enzyme activity is not affected by lactation, pregnancy, or injections of growth hormones.

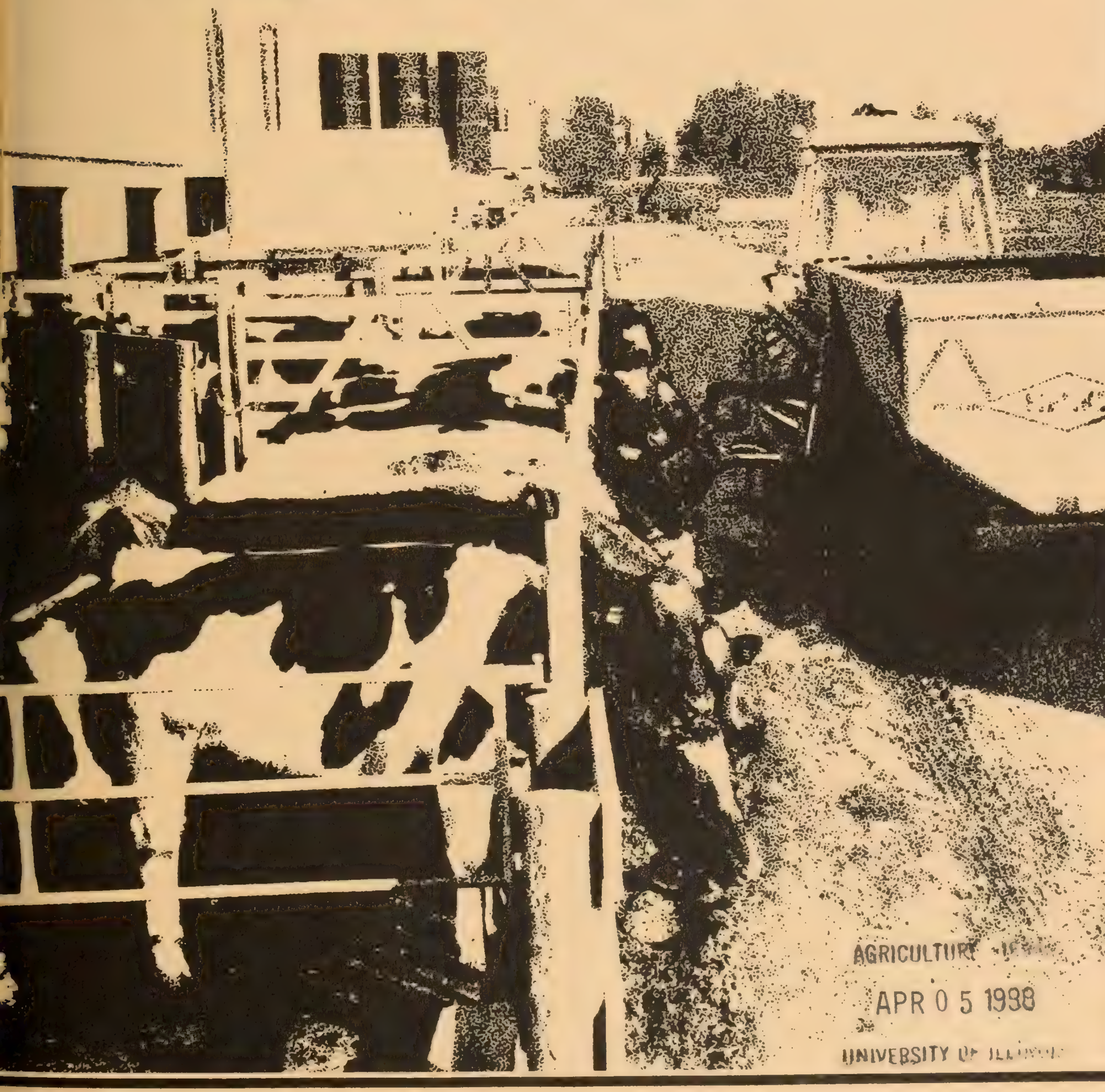
We have identified more than 100 animals as carriers of DUMPS with over 80 percent being female. Fortunately, more than three-fourths of the known carrier males are dead; we do not want the disease to spread. However, if you, as a breeder of dairy cattle, avoid inbreeding, you will find a very low probability of embryonic death due to DUMPS. This probability will increase if the incidence of DUMPS is increased. Therefore, with regard to our quandary, should the dairy industry increase the frequency of DUMPS with both the associated increased milk production and the potential for increased embryonic death in the futre? We cannot recommend it.

[*A portion of this research study was supported by Holstein Association of America.*]

1987
Illinois Dairy Report

Department of Animal Sciences
Cooperative Extension Service
Agricultural Experiment Station
College of Agriculture
University of Illinois at Urbana-Champaign

Making the Difference



1987 Illinois Dairy Days

January 12 Kankakee, Redwood Inn

13 Marengo, Cloven Hoof Restaurant

14 Freeport, Masonic Temple

14 Elizabeth, Community Bldg

15 Sterling, Emerald Hill Country Club

January 16 Pekin, Agricultural Center

20 Quincy, Farm Bureau Building

21 St. Libory, American Legion Hall

22 Breese, American Legion Hall

23 Teutopolis, Knights of Columbus Hall

Authors

Department of Animal Sciences, University of Illinois at Urbana-Champaign, except as noted:

DAVID G. ATWELL, research assistant management

JANICE M. BAHR, professor, physiology

DALE E. BAUMAN, professor, Department of Animal Science, Cornell University

MARK G. CAMERON, research assistant, management

JIMMY H. CLARK, professor, nutrition

WENDIE S. COHICK, research assistant, nutrition

CARL L. DAVIS, professor emeritus, nutrition

PETER S. ERICKSON, research assistant, nutrition

ROHAN L. FERNANDO, assistant professor, genetics

MARY A. GREINER, research assistant, genetics

W. R. (REG) GOMES, professor and head, physiology

GARY W. HARPESTAD, associate professor, Extension dairyman

WALTER L. HURLEY, assistant professor, physiology

MICHAEL F. HUTJENS, professor, Extension dairyman

EDWIN H. JASTER, associate professor, management

TAD KERR, area agricultural engineer, Dixon, Regions 1 & 2

J. ROBERT LODGE, professor, physiology

STUART N. McCUTCHEON, professor, Department of Animal Science, Massey University, Palmerston North, New Zealand

GENE C. McCOY, dairy scientist, management

KENNETH J. MOORE, assistant professor, Department of Agronomy, forage production

MICHAEL R. MURPHY, associate professor, nutrition

RICHARD F. RANDLE, teaching associate, College of Veterinary Medicine

DANIEL J. SCHAUFF, research assistant, nutrition

ROGER D SHANKS, associate professor, genetics

STANLEY T. SMITH, area dairy adviser, Dixon, Regions 1 & 2

CHARLES R. STAPLES, Extension dairyman, University of Florida

JOHN L. VICINI, research associate, nutrition

CINDY L. WEDIG, research associate, management

STEVEN T. WOODFORD, research associate, nutrition

Contents

1987 Theme: Making the Difference

University of Illinois Research Reports

The Department of Animal Sciences
W.R. (Reg) Gomes

Dairy faculty and students in the Department of Animal Sciences have experienced a busy, productive year in 1985-86. As we started the fiscal year, the U.S. government was putting final touches on the Dairy Termination Program and our people were trying to keep up with day-by-day developments so that they could keep you informed. The 1986 Dairy Days appeared before near record crowds, our student activities continued to be well attended and educational, and the contributions of our faculty around the world continued to be recognized.

On Campus in Urbana, we are working with architects to expand and remodel our Animal Sciences Laboratory building and develop new facilities for Chinese pigs, beef cattle, and biotechnology programs. When the work is completed, we will be able to further expand our research, teaching, and extension efforts through better interactions of our faculty, improved space for working, and up-to-date technology for discovery and dissemination of knowledge.

We invite your suggestions and comments concerning our people, programs, and ideas. We appreciate your interest in our 1987 Dairy Days program and invite you to visit us in Urbana.

Dairy Faculty in the Department of Animal Sciences

Faculty	Specialization
Marvin P. Bryant, professor	Ruminant microbiology
Jimmy H. Clark, professor	Dairy cattle nutrition
Charles N. Graves, associate professor	Reproductive physiology
W. R. (Reg) Gomes, professor	Reproductive physiology
Michael Grossman, professor	Dairy breeding & genetics
Gerhard W. Harpestad, associate professor	Extension dairyman
Walter L. Hurley, assistant professor	Lactation endocrinology
Michael F. Hutjens, professor	Extension dairyman
Edwin H. Jaster, associate professor	Dairy cattle management
Bruce L. Larson, professor	Biochemistry and lactation
J. Robert Lodge, professor	Reproductive physiology
Gene C. McCoy, farm manager	Dairy cattle management
Michael R. Murphy, associate professor	Dairy cattle nutrition
James L. Robinson, professor	Biochemistry
Roger D. Shanks, associate professor	Dairy breeding & genetics
Sidney L. Spahr, professor	Dairy cattle management
Bryan A. White, assistant professor	Ruminant microbiology

Using Records for More Profitable Production

Gary W. Harpestad

Having enough income to provide a good living must be a primary goal of dairying. That goal was a challenge for many in 1986 and promises to be an even greater challenge in 1987 and beyond. The name of the game during the rest of the eighties is going to be efficiency. The goal is not the highest production per cow, but the greatest return per cow. Managers must invest their production dollars and efforts where they will receive the greatest return.

To be able to earn maximum income, and sometimes to even survive, producers must identify and solve their production problems related to feeding, reproduction, breeding (genetics), herd health, labor, facilities, and economics. DHI records can provide the catalyst that will make the other inputs work together successfully.

The average expenditure in DHI records is approximately 1 1/2 percent of the cost of producing milk. Some dairy farmers discontinue DHI to save money. This move would save money, but in the long run it would be "penny wise" and "dollar foolish". The average return for an investment in records has been estimated to be over twenty to one.

This return can be accomplished only if the records are used in making sound management decisions. Records are of no immediate value to the herd owner unless they are used. Wisconsin DHI members were asked how they used DHI records. The results of this survey are listed with the percentage: improved production, 92 percent; reproduction, 93 percent; feeding, 89 percent; culling 82 percent; identification, 69 percent; health, 77 percent; and sales, 52 percent.

Using the results, the cost of DHI records can be justified by any of the following points.

1. Increase in milk production of 1/2 pound of milk per cow per day.
2. Save 3 pounds of grain per cow per day during last 90 days of lactation.
3. Reduce calving interval by 5.5 days per cow.
4. Reduce days dry by 5.5 days per cow.
5. Reduce age of first freshening by 1.7 months.
6. Reduce somatic cell count (SCC) to get the dairy's premium.
7. Sale of cattle for dairy purposes.

If records help accomplish any of the above points, the investment is a sound choice. If more than one can be accomplished, records will indeed be an excellent investment.

The purpose of this paper is to present some ways to use records to increase income, reduce expenses, or a combination of both.

PRODUCTION PAYS THE BILLS

Production per cow is the single most important factor in profitable dairying. Minnesota data show clearly that as production levels increase, so does the average dairy management income (Table 1).

Income over feed cost per cow is another way of comparing potential profitability. Again, as production increases, income over feed cost increases as indicated by Mid-States DHIA figures (Table 2). For each 2,000 pound increase in milk production, return to management increases by $110. For each 100 pound increase in production, an additional $5.50 will be available for family living.

Another goal would be to produce at least 15 percent over the breed average if your herd is not already producing at that level. Illinois breed averages in 1985 were 12,176 pounds for Ayrshire; 12,878 pounds for Brown Swiss; 11,569 pounds for Guernsey; 16,009 pounds for Holstein; and 10,186 pounds for Jersey breeds. If you are at that level, a goal of increasing production by 250 to 300 pounds per year should be reasonable. Summit yield is the average of the highest two of the first three sample day milk weights. Each additional pound of summit milk produced means an extra 215 pounds of milk for the year. Top production is required if you are to remain competitive.

FEEDS AND FEEDING

Feed costs usually compromise 40 to 50 percent of the total cost of milk production. Since feed is a large proportion of total costs, feeding is an area where major cost efficiencies can be achieved. Producers should explore ways of growing and harvesting higher quality forages. DHI records should be used to feed more efficiently and get more milk per cow. The summary of over 1,000 Illinois DHIA Holstein herds show increased feed efficiency as production increases (Table 3). DHI records show that many cows are underfed in early lactation and overfed in late lactation. Underfeeding will prevent cows from producing up to their genetic potential. Overfeeding in mid and late lactation will result in higher feed costs and cause metabolic problems.

REPRODUCTION

For some herds, the greatest opportunity to improve profit is through better herd reproductive efficiency. Reducing the calving interval can improve net profit by eliminating long dry periods, minimize low daily production, decrease veterinary bills and breeding costs, and having more calves born. Studies show that a cow loses $1 per day for each day between 365 and 395 day calving interval. That figure is increased to $3 per day for all days over a 395 interval.

Even though research show that high producers can be more difficult to get bred, DHI figures illustrate that high producing herds do just as well as low producing herds in reproductive efficiency (Table 4). The herd manager of a high producing herd works harder at achieving comparable performance. DHI records contain a great deal of information in the reproduction area.

SOMATIC CELL COUNT (SCC)

The National Mastitis Council estimates the loss to mastitis at about $200 per cow per year. Seventy percent of these losses are attributed to reduced milk production due to subclinical mastitis. The best way to detect individual cows with subclinical mastitis is through the regular use of DHI SCC test. A comparison of 548 Iowa Holstein herds proves conclusively that cows with low SCC produce more milk (Table 5). Recent implementation of linear scoring for S.C.C. has made these losses easier to understand and interpret. Each increase of a linear point doubles the SCC and represents a loss of 1.5 pounds of milk per day. The entire industry benefits from production of high quality milk. Many plants are now paying milk quality premiums for low somatic cell milk. Some producers miss out on this potential for increased income due to high levels of subclinical infection in their herds.

CULLING

DHI records have long been used in determining which cows to sell because of low production. Many herds could increase their net income by culling the lowest producers. This point was proven during the dairy diversion program several years ago when many dairy managers sold 25 percent of their cows and still produced about the same amount of milk. Records can point out which cows to sell and the most profitable time to sell them. DHI cooperators can obtain a culling guide which lists likely culling candidates. An even better way to obtain a culling list is to order a <u>Flexible Management Report</u> (FMR). Request such information as barn name, difference from herdmates milk, sample day SCC, fresh date, lactation number, days in milk, sample day income over feed cost, or due date. By having this report listed from low to high on difference from herdmates, the entire herd will be listed with the most likely culling candidates listed first.

GENETICS

Sires have the greatest impact on genetic improvement in dairy herds. Cows sired by high P.D. sires produce more milk than cows sired by low P.D. sires. A direct correlation exists between herd production levels and the percent of animals sired by sires with known P.D.'s. In addition, herds that are producing more milk per cow are using service sires with higher P.D.'s to insure their future competitive advantage (Table 6). In the most recent sire summary (July, 1986) the average daughter of an active AI sire produced 1,113 pounds more milk and 130 P.D. dollars more than the average non-AI daughter. Dams of the future animals in herds also contribute to the genetic merit of the animals.

DHI records help to obtain inforamtion for sire summaries, cow evaluations, and to help producers make decisions using this genetic information. The high producing herds have genetically superior cows in the herds and will continue to have genetically superior cows in the future.

Parts of this paper were adapted from a Search For Hidden $ in Your DHIA Records prepared by Ron Orth, Extension Dairy Specialist, Iowa State University.

Table 1. Southeastern Minnesota Farm Management Association

	Low 20%	Average	High 20%
Milk production/cow (lb)	12,288	14,974	17,647
Milk sold (lb)	12,156	14,788	17,492
Value milk sold per cow ($)	6,625	1,957	2,344
Gross production per cow ($)	1,551	1,886	2,267
Total direct costs ($)	1,231	1,338	1,304
Total overhead costs ($)	471	549	621
Net return ($)	-151	108	342
Average number of cows	51	60	66

Table 2. Comparison of Income/Feed Cost at Various Production Levels.

Income over feed cost ($)	Average annual milk yield (lb)
405	10,140
656	11,456
896	12,847
1120	14,405
1359	15,999
1591	16,708

Table 3. Feed Efficiency of Illinois DHIA Herds

Milk (lb)	11,922	14,387	16,245	18,341
Milk to grain (lb)	3.5	3.1	3.0	3.1
IOFC/cow/yr ($)	784	1,054	1,208	1,395
FC/cwt milk ($)	5.43	4.76	4.63	4.41
Return over feed fed ($)	2.34	2.70	2.73	2.86

Table 4. Reproductive Comparisons at Different Production Levels of Illinois Holstein Herds.

Milk (lb)	11,922	14,387	16,245	18,347
Freshening interval-pregnant cows (days)	399	420	401	400
Services per conception	1.7	1.8	1.8	1.9
Days to 1st breeding	90	90	89	90
Days open	147	111	95	76
Days dry	72	67	65	61

Table 5. Comparison of SCC and Milk Yield

Herd Average S.C.C.	Milk (lb)	Fat (lb)	Test Milk (lb)
322,000	15,271	554	48.7
433,000	14,037	512	44.8
961,000	13,086	479	42.2

Table 6. Genetic Information on Illinois Holstein Herds and Different Levels of Production

Production Level (lb)	% Sires with ID	% Cows from sires with PD	% Cows bred to sires with PD	Avg. PD$ of service sires
<13,000	33	- 70	47	+719
13,000-15,000	53	+110	58	+776
15,500-17,000	69	+218	69	+824
>17,000	81	+304	74	+853

Fine Tuning Dairy Rations

Michael F. Hutjens

Feed costs represent the largest expenditure in the dairy operation. Since most dairy farmers raise forages and grains for their dairy herds, they are in a good position to control and influence both the feed program and its subsequent profitablility. Typical midwest feed inputs and costs are summarized in Table 1. A 1986 survey of 964 Illinois DHI dairy herds reflects the variaiton in feeding dairy cattle (Table 2). In order to maximize profits in 1987, each dairy manager must review and adjust both the feeding program and approaches.

FORAGE QUALITY

Forage is the backbone of dairy rations. This year, several factors should be considered when feeding forage: (1) forage amounts will be abundant; (2) forage prices appear to be low; and (3) forage quality will vary due to the winter kill of alfalfa and wheat, rain damage to the first crop, and forage harvested from diverted corn acreage. Strategies for 1987 include maximizing forage intake without sacrificing performance, testing forages to monitor changes in quality and nutrient value, and planning ahead to control forage inventories to minimize feed costs. Lower quality forage should be fed to older replacement heifers, dry cows, and low milk producers. Forage should cost less than one dollar per cow and under 45 percent of the total feed costs for the milk herd.

OPTIMIZING GRAIN MIXTURES

Corn will also be inexpensive in 1987, and in several areas, oats will be a competitive buy compared with corn. By-product (coproduct) feeds must be evaluated economically because several of 1985s good buys should not be purchased this year. The correct amount of grain (energy levels) and protein supplements should be fed to avoid over- and underfeeding. Several factors used for determining grain needs include forage intake, forage quality, milk yield, fat test, body weight, stage of lactation, body weight change, and age (Tables 3 and 4). Farmers that can topdress protein supplements or use dual feed electronic grain feeders can capitalize through individual feeding. Total mixed rations (TMR) and grain mixtures fed at various locations (bunk, parlor, and with silage) could also provide flexibility.

Since the amount of grain fed may be higher this year, the following guidelines can be used to minimize rumen digestive problems and low fat test: (1) limiting grain intake to 5 to 7 pounds per meal; (2) adding a fiber component to the grain mixture if "slug" feeding occurs

(beet pulp, oats, and ear corn are examples); (3) feeding 2 to 4 pounds of forage dry matter prior to a heavy grain feeding; and (4) adding a buffer pack can improve the rumen environment.

CALF STRATEGIES

The main goal in the calf program is to raise a healthy, growthy heifer that is ready to wean and move to the heifer rearing facility. Soured colostrum, fed after two days of fresh colostrum, is an excellent feed. Only 2 percent of Illinois DHI herds are using this practice, which is unfortunate since it could save $15 to $30 per calf (replaces milk or milk replacer). However, if soured colostrum is not fed, whole milk is the next best alternative, followed by a top-quality milk replacer (22 percent protein, 10 to 20 percent fat, and less than 0.5 percent fiber). The best quality milk replacer should be fed the first three weeks after birth; then a cheaper and lower quality product can be used. Prestarter and dried fat products provide alternatives for improving growth and provide extra energy to calves exposed to cold and stress. The sooner calves consume dry feed, the sooner they can be fed more inexpensively. When the replacement heifer is consuming 1 to 2 pounds of a high-quality calf starter, weaning can occur.

HEIFER STRATEGIES

Ideally, five different heifer diets should be fed to heifers from 2 to 24 months of age (Table 5). A critical heifer growth period is from 3 months of age through puberty. During this period, excessive energy intake will decrease mammary tissue formation, depress growth hormone levels, increase fat deposition in the immature mammary gland, and lower milk yield potential when the heifer calves. Underfeeding will slow growth and delay breeding. Growth rates over 1.5 pounds per day and under 1.8 pounds are ideal for large breed heifers. Small breed heifers should grow at 1.3 to 1.4 pounds per day. The ultimate goal is a large heifer (1,200 pounds for a Holstein) by 24 months of age.

Monensin (brand name of Rumensin) continues to receive positive comments from producers and veterinarians. Heifers over 400 pounds can be fed 100 to 200 milligrams of monensin per day at a cost of slightly more than a penny. Feed efficiency and growth improvement average 9 to 10 percent. No negative side effects have been reported by researchers. Since heifers may go off feed when they are first fed monensin, reduce the level of monensin to 50 to 100 milligrams for several days. Lower levels are also suggested for young heifers.

MILKING HERD GUIDES

Dairy managers must recognize that their dairy herds consist of several groups of cows with different nutrient needs, variable feed intakes, and nutritionally related health problems (Table 6). Dry cows

must have a specific and separate feeding program which is fortified with the correct levels of minerals and vitamins in less dry matter, compared with that for lactating cows. Early lactation cows eat less, mobilize body fat, and peak in milk yield which also requires a unique ration.

Low degradable protein sources should be used in high producing cows (over 70 pounds of 4 percent FCM) rations to meet protein needs for milk yield and tissue replacement. The quality or amino acid profile of the low degradable protein source should also be considered because alfalfa, corn, corn by-product, and some cereal grains can be low in lysine, methionine, and other amino acids.

Supplementing fat or oil to cows in early lactation which are losing body condition can improve milk yield, fat test, reproduction, and general health. Current guidelines suggest adding 1 to 1 1/2 pounds of fat or oil per cow. Animal fats are superior to unsaturated vegetable oils. Blended fat and oil products, spray-dry fat sources, and protected fats and oils will be available commercially, but cost: benefit ratios should be reviewed. Oilseeds (3 to 4 pounds of raw soybeans, 5 to 6 pounds of heat-treated soybeans, 5 to 6 pounds of whole cottonseed, or 2 pounds of sunflower seeds) can be economical sources of oil.

A new concept some producers have adopted is formulating for an optimal balance of soluble carbohydrates (sugars and starches) and nonstructural carbohydrates (neutral detergent fiber). Excess soluble carbohydrate (Sol-CHO) can cause rumen acidosis, low fat test, off-feed, and laminitis. Excess nonstructural carbohydrate (Non Sol-CHO) will lower feed intake and energy concentration. Guidelines are a maximum of 30 percent Sol-CHO and a minimum of 27 percent Non Sol-CHO. Practical application of this concept is adding beet pulp, oats, or soyhulls to a shelled corn-based grain mixture; feeding less grain with top quality forage; and an improved fat test after high-moisture ear corn replaces high moisture shelled corn.

Feed additives are used to improve ration performance for lactating cows. Several of the current additives being used are listed below.

- Niacin (a B vitamin) can improve milk yield and feed intake and decrease ketosis. Six grams of niacin fed 1 to 2 weeks prepartum to 10 to 12 weeks postpartum is the recommended level.

- Buffers may increase dry matter intake and fat test while maintaining an optimum rumen environment when 1/4 to 1/2 pound of sodium bicarbonate or its equivalent is fed for the first 120 days after calving. Magnesium oxide (1/10 to 1/5 lb) as part of the buffer pack is recommended.

Several other feed additives can be considered, but research or field response has been variable: isoacids (1 1/2 ounces two weeks prepartum and 3 ounces per day for 225 days after calving); choline (50 grams per day for the first 100 days after calving); yeast (1/4 pound per day when cows are stressed); zinc methionine (4.5 grams per day to improve feet condition); methionine analog (30 grams per day for 120 days after calving); and beta-carotene (200 to 300 milligrams per day fed one week before calving until the cow is diagnosed pregnant). The economic return on each additive must be evaluated since responses will vary from herd to herd due to differences in milk production, forages fed, herd health, and feeding systems.

Table 1. Feed Related Costs and Guidelines for the Dairy Operation

	Feed costs
Milking cows	
12,000 lb/yr	$665
16,000 lb/yr	$830
20,000 lb/yr	$990
Heifers	
0-3 months	$ 42
3-12 months	$153
12-24 months	$326

Table 2. Feed Practices Reported on 982 Illinois DHI Herds in 1986

Feed item	% Herds	Feed item	% Herds
Grain feeding location		Type of grain	
Tiestall barn	60	Dry ear corn	31
Milking parlor	26	Dry shelled corn	48
T.M.R.	10	Oats	39
Computer feeder	5	H.M. shelled corn ...	23
Magnetic feeder	4	H.M. ear corn	6
Bunk	15	Soyhulls	2
Protein supplement		Distillers' grain ...	6
Commercial, no urea	50	Corn gluten feed	10
Commercial, urea	9	Brewers' grain	3
Soybean meal	46	Wholecotton seed	2
Soybeans	4	Buffer use	50
Separate dry cow ration	45	Use soured colostrum ..	2
Monensin to heifers	18	Deworm heifers	38

Table 3. The effect of forage quality on concentrate feeding guidelines (1200 lb cow)

Milk yield (lb)	Fat test (%)	Legume[1] Shelled corn (lb)	Legume[1] SBM (lb)	Leg-grass[2] Shelled corn (lb)	Leg-grass[2] SBM (lb)	Grass[3] Shelled corn (lb)	Grass[3] SBM (lb)
30	3.9	7	0	9	0	10	1
50	3.7	15	0	15	2	16	3 1/2
70	3.5	21	1	21	4 1/2	21	6
90	3.3	27	4	26	7	26	8
100	3.1	31	6	31	9	31	10

[1] Contains 20% crude protein, .63 Mcal per lb, and 32% ADF.

[2] Contains 15% crude protein, .59 Mcal per lb, and 35% ADF.

[3] Contains 12% crude protein, .55 Mcal per lb, and 40% ADF.

Table 4. Grain (shelled corn and protein supplement (soybean meal) needed for a 25% corn silage-75% legume (18% crude protein) forage ration with various production factors.

Variable	Shelled corn (lb)	Soybean meal (lb)
Milk yield[1]		
30 lb	1.0	0
50 lb	9.2	0
70 lb	18.9	2.9
90 lb	25.7	5.9
Milk fat test[2]	±1.2	±.5
Lactation number (growth)		
1st	+1.0	+.3
2nd	+0.5	+.1
Stage of lactation[3]	+4.2	+1.8
Body condition changes		
Gain 1 lb	+2.9	+.1
Loss 1 lb	-2.8	-.1
Body weight[4]	± .6	0

[1]Standard values used: 1400 lb body weight and 3.5% milk fat.

[2]Change with a shift of .5% (ie 3.5 % to 4.0%).

[3]Lead factor of 7.5 percent above 60 lb.

[4]Effect of each 100 pound change in body weight.

Table 5. Suggested ration specifications for growing heifers (University of Wisconsin)

	Age (months)			
	4-6	7-12	13-18	19-22
	Average weight (lb, large-breed heifers)			
	300	550	800	1100
Estimated dry matter intake				
lb/day	7-9	12-16	17-21	22-26
Percent of body weight	2.7-3.0	2.7	2.5	2.0
	Nutrient specifications (% of dry matter)			
Crude protein	15-16	14-15	12	12
TDN	68-74	62-78	60-63	58-60
Calcium	.60-.75	.50-.60	.50-.60	.40-.50
Phosphorus	.35-.40	.32-.35	.28-.32	.28-.30
Trace mineral salt	>.25	>.25	>.25	>.25
Acid detergent fiber	19	19	22	24
Forage	20-60	30-90	40-100	40-100
Vitamin A (IU/lb DM)	1,000	1,000	1,000	1,000
Vitamin D (IU/lb DM)	300	300	300	300
Vitamin E (IU/lb DM)	10	10	10	10

Table 6. Recommended nutrient content for dairy cow rations.

	Dry cows	Phase 1 (0-80 days)	Phase 2 (80-200 days)	Phase 3 (Over 200 da
Crude protein (%)	12	18	17	13
TDN (%)	56	75	75	67
Net Energy-Lact (Mcal/lb)	.57	.78	.78	.69
Acid detergent fiber (%)	27	18	19	22
Neutral detergent fiber (%)	35	25	28	30
Ether extract (%)	3	5	5	3
Calcium (%)	.37	.80	.80	.60
Phosphorus (%)	.26	.50	.45	.40
Magnesium (%)	.16	.30	.25	.20
Potassium (%)	.65	1.00	1.00	.90
Sodium (%)	.10	.30	.20	.20
Chloride (%)	.20	.25	.25	.25
Sulfur (%)	.16	.20	.20	.20
Iron (ppm)	100	100	100	100
Cobalt (ppm)	.10	.10	.10	.10
Copper (ppm)	15	15	15	15
Manganese (ppm)	50	50	50	50
Zinc (ppm)	60	60	60	60
Iodine (ppm)	.25	.60	.60	.60
Selenium (mg)	5	5	4	3
Vitamin A (IU)	100,000	100,000	50,000	50,000
Vitamin D (IU)	30,000	30,000	20,000	20,000
Vitamin E (IU)	400	400	200	200

Identifying Reproductive Problems

Stanley T. Smith

Maintaining good reproductive performance should be a top management priority of dairy herd operators. Reproductive failures mean longer calving intervals and delayed calving of heifers. Late entry of first-calf heifers into the milking herd adds to the cost of raising herd replacements and delays the time that they begin contributing to the income.

ECONOMICS OF REPRODUCTIVE PERFORMANCE

The reproductive status of a dairy herd has a large bearing on production and profitability. Those factors affecting the economic consequences of reproductive failure are listed below.

1. The number of calves born yearly affects future herd replacement rate, future genetic improvement, and potential animals available for sale.

2. Cows culled for poor reproductive performance reduce the opportunity to cull for production or increase the cost of raising more herd replacements needed to maintain the herd size.

3. The maintenance of a herd calving pattern that makes optimal use of labor and facilities available may be important on diversified farms.

4. The pounds of milk produced per day of a cow's life in the herd is greater. Short calving intervals result in cows spending more days producing nearer their peak levels; however, this requires firm management to insure at least 50 day dry periods so as not to reduce the performance of the subsequent lactation. Generally, the profitability of lower producing cows (below 14,000) is enhanced with short calving intervals (12 months or less). Recent evidence would indicate that even in very high producing cows, a 12.5 to 13 month interval is the ideal. The optimum interval for first lactation cows is about 13 months because of their greatest persistency.

5. The increased cost of semen, veterinary services, drugs, and therapy are also problems associated with poor herd reproduction.

Of the losses listed above, only number 5 represents an actual cash cost. The others are difficult to measure in that they represent a loss of potential income rather than a cash loss. How do you assign a value to the milk a cow does not produce or determine the value of a calf that was never conceived? A similar question can be asked about the reduction in genetic progress because animals must be culled for reproductive failures. This limits the ability to cull low producing animals.

Nonetheless, it is necessary to attempt to place some value on these factors. It is important to know costs and potential benefits when making management decisions. It is commonly quoted in the research literature and popular press that losses ranging from $1.50 to $5.00 per cow per day can be expected for each day in excess of the ideal 12 month calving interval. Calving interval and other commonly used reproductive indices and their respective estimates of economic loss are listed in Table 1. Recent Illinois DHI figures are listed below.

• Calving interval	404	days
• Average days open	125	days
• Average days dry	64	days
• Services per conception	1.8	services
• Average days in milk	174	days

Comparing these to the loss estimates in Table 1 would produce an annual estimated loss between $110 and $150 per cow. Herds below average could have losses exceeding $200 per cow annually. A report from the National Invitational Dairy Cattle Reproduction Workshop is summarized in Table 2.

IDENTIFICATION OF REPRODUCTIVE PROBLEMS

The first step in the solution of any problem is to identify the problem to be solved. You can't hit the bull's eye until you have located the target. Reproductive failure can be caused by a single factor or more often, by a combination of factors.

Accurate and complete reproductive records are a must when identifying problems or making decisions to solve those problems. There is an old management adage that says "You can't manage it if you don't measure it." Simply improving the record keeping system on many farms would result in improved performance. Problems would be more correctly identified so that management decisions could be made that would directly address these problems.

Days open is the single most important indicator of reproductive efficiency. Cows cannot be open longer than 115 days if the goal is to have a 13 month calving interval. A reasonable goal for well-managed herds would be 90 to 110 days open. This would translate to a 12.1 to 12.8 month calving interval.

DRY PERIOD LENGTH

Exceptionally long or short dry periods will adversely affect profitability of individual cows. A short dry period will not give cows adequate rest and time for mammary involution and regeneration. Long dry periods result in higher feed costs with no milk production return and frequently overconditioned cows. These individuals often have problems at calving or in early lactation. Table 3 indicates how dry period length affects a cow's production in the following lactation.

NUTRITION AND REPRODUCTIVE PERFORMANCE

There are no nutrients needed for reproduction that are not also required for growth, milk production, and maintenance. Reproductive problems that may be due to faulty nutrition are:

- Delayed estrus (heat) in heifers and cows
- Poor conception
- Irregular heat periods
- Anestrus (no heat)
- Abortion
- Weak or dead calves at birth

Determining exact dietary needs for reproduction is extremely difficult because lowered fertility may result from one or a combination of causes. Malnutrition seldom can be attributed to a lack of just one nutrient in the feed.

FEEDING THE COW

Most cows fed for production and profit according to the challenge concept receive ample energy to come into heat within 60 days after calving. But undernourished cows show irregular heat periods, low fertility, and complete cessation of estrus in severe cases.

Energy is the fuel animals burn to keep all of life's processes functioning including reproduction. The animal's energy needs for reproduction are not great compared to her requirements for milk production, growth, or maintenance. But all these life processes compete with each other for the energy received. When rations are short of energy, it is the most common cause of nutritional reproductive problems; heifers may come into first heat late and cows may not cycle regularly or may not settle.

Dairy cows are normally in peak production at breeding time. Because of the heavy demand for energy by high milk production, you must provide enough energy to keep the reproductive organs functioning properly. More difficulty usually is encountered when a cow is losing weight than when she is gaining weight.

The following points are some strategies for helping the cow meet her energy needs during the first 10 weeks postpartum.

1. Provide extra protein and minerals to help the cow use body fat as an energy resource.

2. Control body weight loss to avoid ketosis. Niacin, a B vitamin, may be beneficial when supplemented at 6 grams per cow per day from 7 days before calving to 10 weeks after calving.

3. Encourage maximum dry matter intake by feeding top-quality feeds, by feeding frequently, and by providing buffers to stabilize rumen and dietary changes.

4. Consider adding fat to increase energy concentration and maintain fat test.

It is challenging to get a high-producing dairy cow to eat enough to prevent excessive body weight losses. The job may be easier if the cows are not allowed to get too fat while they are dry. Fat cows may be finicky eaters. Such reduced appetites add to the difficulty of getting enough feed into them during this critical period.

MANAGEMENT FACTORS

The two most important management factors relating to reproductive performance are heat detection and conception rate. The job a dairy producer does in these two areas forms the foundation for reproductive efficiency in the herd.

Heat Detection

Poor heat detection is the greatest single obstacle to successful A.I. programs. Minnesota studies involving large numbers of cows show that detection of heat is more of a management problem than a cow problem. Ninety percent of all cows thought to be anestrus (not showing heat) were cycling normally. Only 10 percent of supposedly anestrus cows were actually not cycling as a result of some pathological problem.

Well fed and healthy cows will normally begin to cycle by approximately 20 days post partum (after calving). Not all of these early ovulations are accompanied by strong heat signs. However, by 60 days postpartum, nearly 100 percent of normal cows are cycling and expressing normal heat signs. Whether or not these cows are observed in heat depends on the intensity of the heat detection effort.

With nearly one-fourth of heats lasting 8 hours or less, it becomes obvious that the number of heat observations and the length of observation periods during the day will have a large effect on the percentage of cows which will be observed in heat.

Research work in England, Canada, and the U.S. point out the effect of time of day on mounting activity. These studies indicate

that nearly 40 percent of the mounting activity in a dairy herd occurs between midnight and 6:00 a.m., with nearly 30 percent occurring between 6:00 p.m. and midnight. About 20 percent of the mounting activity occurs in the morning and the remaining 10 percent in the afternoon hours. These data would indicate that if a program is to be successful, it should, at minimum, include heat observation prior to the morning milking, at the conclusion of the evening milking, and sometime in mid to late morning. These times would have the best probability of finding the largest number of individuals in heat.

English researchers found that a higher percentage of heats were detected when herds were observed for periods up to 30 minutes. These results are attributed to the fact that cows seldom exhibit standing heat constantly but rather tend to be mounted at intervals of 15 to 20 minutes. A short observation of only 5 or 10 minutes will miss some of these individuals. Some other factors that affect finding cows in heat are listed below.

1. Slippery floor surfaces where cows are unsure of their footing will reduce mounting activity.

2. Less mounting activity will occur when cows are eating than when they are allowed to socialize.

3. Cows with sore feet or injured legs are less likely to show heat.

4. Hot and humid weather, rain, ice, snow, and wind tend to reduce heat activity.

5. Cows or heifers in a low feed energy state often fail to show heat.

It is also important to schedule observation periods so that they do not interfere with other activities which affect the herd's behavior. For example, cows that are eating, have been confined to a holding pen, or are attempting to avoid movement of equipment during waste-handling procedures may not show symptoms of heat.

Estrus-Detection Aids

In recent years, a number of heat-detection aids have been developed in an effort to facilitate visual observation and to provide 24 hours detection. The most popular and most widely studied aids are (1) those that are glued to the rump of the cow or heifer and (2) a marking harness (chin ball marker) which is applied to a sexually aggressive animal.

Illinois research has shown that these heat detectors can be useful as long as they are properly placed and replaced and the signs properly interpreted. The application of the detector in the proper location and the use of plenty of glue on unclipped hair are essential. Two main problems, other than the time and cost, are lost detectors and the interpretation of partially activated detectors.

A similar technique being used successfully by some dairy producers is the application of colored chalk or crayon on the tailhead. Any animal showing a smudged or erased mark probably was in heat. This, too, could be done accidentally. If so, the chalk mark would have to be applied again.

Chin ball markers have been used on variously prepared bulls, cystic cows, and hormone-treated steers, heifers, or cows. The results vary with the method used. Most studies indicate the best job is done by a bull that has been surgically altered to prevent penetration. This eliminates the potential of spreading disease. Some studies with hormone treated females have shown good results, but some have not demonstrated the degree of mounting activity that a bull does.

Other methods of heat detection are in the experimental stage and may or may not be useful on a practical basis. These include the use of pedometers for measuring increased walking activity, vaginal probes to measure estrus-associated changes in the electrical resistance of mucus, ways of measuring changes in milk temperature, electronic measurement of animal activity, rapid assays of milk or blood hormone levels, and videotape monitoring.

Dairy farmers in Europe have used a test for milk progesterone levels quite extensively. Recently a new procedure has been developed to determine milk progesterone levels with a relatively simple cowside test. This shows much promise as a further aid in reproductive management.

It must always be kept in mind that heat detection aids would be used to supplement visual observation and to identify that small percentage of animals which are in heat only a short time or exhibit low intensity and are not likely to be observed. The best measure of heat is the visual observation of an animal standing while she is being mounted by another animal. Aids can assist in this detection process, but are no substitute for visual observation.

Conception Rate

A poor conception rate can be a contributing factor to a high number of days open. It is generally considered that 1.5 to 1.8 services per conception is acceptable performance. It is extremely difficult to attain a figure less than 1.5 and a figure of 2.0 or more indicates real problems.

The cost estimate from Table 1 indicates that it costs $1.50 per cow for each .1 service per conception over 1.5. When valuable semen is used, this estimate can be too low. Problems with conception rate may be caused by several factors listed below.

1. Timing of insemination
2. Insemination techniques
3. Semen quality and/or handling
4. Infection or diseases
5. Nutrition

Importance of Timing

In order to fully appreciate the importance of proper timing of the service, one must keep in mind a few important facts concerning the function of a cow's reproductive system and the life of a spermatoza.

1. A cow or heifer is not actually in heat until and unless she stands to be mounted. Other signs of heat must be considered as suggestions that she might be in heat, coming in heat, or that she might have just been in standing heat.

2. The average length of standing heat in a cow is 15 to 18 hours.

3. Ovulation, or the release of the egg, does not occur until 12 hours after the end of standing heat.

4. After being released from the ovary, the egg has a fertile life of 10 to 12 hours.

5. Sperm have a total life of 24 to 30 hours after they have been deposited in a cow's reproductive tract. They may not be fertile during the first 4 to 6 hours while they are becoming capacitated.

6. Sperm are carried from the site of deposition to the site of fertilization within a few minutes. Therefore, sperm transport is not a factor in determining the optimum time of service.

Conception rate depends upon a good heat detection program. Cows that are healthy and that are observed in standing heat with a properly timed service have an excellent chance of conceiving. The timing of service is of particular importance when using A.I. The more frequent the observations are, the more likely one can pinpoint the beginning or end of standing heat. The major objective is to have live, viable sperm in the reproductive tract at the time of ovulation. Breeding at the end of standing heat will provide live sperm in the reproductive tract 10 to 12 hours before and 10 to 12 hours after the expected time of ovulation. This gives greater coverage for individual cows that may be either "early" or "late" in ovulation. This further points out that the importance of timing the service properly does not mean that each cow must be bred with pinpoint accuracy. In most cows, service can be timed within a 12 to 15 hour period and receive satisfactory results.

Estrus Synchronization

Products are now on the market that will synchronize estrus by controlling ovulation. How these fit into a reproductive management program depends upon the product used. In general, animals can be bred at observable heat after administration or animals can be bred at a

specified time after removal of the product. Either of these plans should result in satisfactory conception rates. Nearly all studies show slightly lower conception rate from timed breeding as opposed to observed estrus.

Any synchronization program requires proper facilities and labor as well as careful planning and cooperation among the herd manager, veterinarian, and inseminator. Synchronization products cannot overcome poor management and should not be expected to improve the rate of conception under a poorly managed program.

HEALTH CONSIDERATIONS

A regular vaccination program should be established to minimize disease problems. Care should be exercised when purchasing animals.

Establishing a regular reproductive examination program with your veterinarian can be of great value in improving overall reproductive performance. These plans will vary depending upon the wishes of the herd owner and the veterinarian. However, successful programs contain several factors.

1. A post-calving exam (20 to 40 days) to see that the reproductive tract is returning to normal, non-pregnant status. These exams can detect problems early and treatment be given early so that cows get in shape for breeding.

2. Pregnancy exams (35 to 50 days post-breeding) to confirm pregnancy or identify problem cows that have not settled.

3. Regular re-examination of problem cows to see if they are responding to treatment.

SUMMARY

While there are many factors affecting reproductive efficiency, major emphasis should be placed on the following points.

1. adequate nutrition

2. sound health program

3. good heat detection

4. accurate timing of service

5. regular reprodutive exams

All of these will be enhanced with an accurate and up-to-date record program. The records will provide a measure of performance and be the basis for analysis if problems occur. Additionally, they will help discover problems before they reach major proportions.

Table 1. Indices Commonly Used to Monitor Reproductive Performance and Their Respective Estimates of Losses Incurred by Suboptimal Reproductive Performance.

Reproductive measure	Suggested goal	Loss estimates
Calving interval	12-13 months	\$1.50-\$5.00/cow/day loss for each day beyond a 12-month CI
Avg. days open	90-110 days	\$2.00/cow/day for each day beyond 90
Avg. days dry	60 days	\$2/day each day <40d \$3/day each day >60d
Services per conception	1.5	\$1.50/cow/each 0.1 over 1.5
Avg. days in milk	150-170 days	0.17 lb/cow/day > 16,000 lb production 0.13 lb/cow/day < 16,000 lb production

Table 2. Total Cost of Low Fertility

Item	Cost/Cow
Milk losses	$ 62.11
Calf losses	12.20
Replacement costs	30.94
Veterinary services and medication	6.00
Additional breeding costs	5.00
Annual loss per cow	$116.25

Table 3. Days Dry Related to Milk Production in the Following Lactation Expressed as the Difference in Lactation Milk Production from Herdmates for 281,816 Cows. (Source: North Carolina State University DHI Processing Center).

Days dry	Difference in production from herdmates (lb milk)
40	+ 14
50	+253
60	+315
70	+247
80	+118

Energy Issues and Conservation for Dairy Farms

Tad Kerr

Energy is not currently a priority concern of the dairy producer. In some respect, this lack of concern is justified since no energy shortages have occurred recently. A review of history over the last 15 years may remind us how quickly the energy picture can change. Recall, for example, the following events.

- Oil embargo of 1973
- Natural gas crisis of 1975
- Coal strike of 1976
- Iranian oil cut-off of 1978-79
- Gasoline shortages in 1979
- Uncertain diesel fuel supplies of 1979

Recent energy trends and the economic picture should cause many dairy managers to rethink energy issues. These issues range from the relative cost of different energy sources to the quality of that energy. The dairy enterprise must consider the technological and managerial changes that will result in energy savings.

ENERGY EXPENSES

Work by the University of Vermont has shown the energy cost per cow for a "typical" farm will average about $0.68 per hundredweight of milk. The range of energy costs were between $0.50 and $1.12 per hundredweight of milk and shows that a wide variation between energy management does exist. On a per cow or per hundredweight of milk basis, total energy cost differed little between stanchion and freestall systems. A difference was found in which areas the energy usage occurred. On a per cow basis, parlor systems with freestalls required more energy for manure hauling, lighting, and raising replacements. This was offset by the parlor/freestall system using less energy per cow for milking and water heating.

MAJOR ENERGY USES

Energy usage on the farm can be divided into liquid (portable) fuel and electrical (non-portable) fuel. For a parlor/freestall operation the electrical energy component accounts for 46 percent of the total energy used and the portable fuel component the remaining 54 percent. Milking in a barn reverses the energy usage in which the majority (55 percent) of the energy used is electrical and the remainder portable fuel component is 45 percent. This signals that the greatest savings are possible in different areas depending upon the type of milking operation.

The major uses of liquid fuel are for forage production, grain production, manure hauling, and farm travel. Of these, the single

largest component is in grain production which accounts for 50 percent of the total. The remainder is almost equally split between manure hauling and forage production.

Electrical usage includes milking, milk cooling, water heating, space heating, replacement raising, feed processing, feeding, and lighting. As much as 40 percent of the electrical energy used on a modern dairy farm is used to cool milk and heat water. Heat exchangers that cool milk and heat water are extremely effective in reducing this energy component and should be utilized wherever possible.

COMPARING ENERGY COSTS

Energy comparisons can be made by using Table 1 which shows the cost per million BTU's for different fuels. When the new equipment is purchased or old equipment is replaced, decisions involving the relative cost of different energy sources, the purchase cost of the equipment, relative life expectancies, future energy price trends, interest cost, and the time value of money are necessary. Accurate predictions of future energy costs play major roles in the decision making process and makes the purchase of new or replacement equipment difficult. In many cases, using only a 2 or 3 year estimate of future energy cost is the best and most practical basis for making an energy related purchase.

INSULATION

One of the least understood components of the energy picture is the use of insulation in dairy housing. Traditionally, insulation has been viewed as an energy conservation measure. Dairy operations require very little energy for space heating and if fuel is not used, little energy savings can result. Economic benefits from small amounts of insulation do occur because of increased building life and increased animal comfort.

Figure 1 shows the reduction in heat loss by insulating a metal roof and sidewall with 1 inch and 3 inches of expanded polystyrene insulation. As you can see, the initial insulation provided the greatest benefit. Tripling the insulation will reduce the heat loss by an additional 9 (95.1 to 86.3 percent). More benefit can be received by insulating the sidewalls of a typical building than by merely tripling ceiling insulation.

The effect of insulation on the comfort and productivity of dairy animals depends upon several factors. Animals lose or gain heat to the environment by radiation, convection, and conduction. Insulation effects the temperature inside the building and the temperature of the interior building surface. The rationale for using insulation in housing systems depends upon the environment desired and is normally classified as either warm housing or cold housing.

COLD HOUSING

Freestall sheds, loafing sheds, and calf hutches are considered cold housing units. In most cold barns with mature animals, no insulation is normally used. The environment in such buildings will be adequate if clean dry bedding is maintained and plenty of airflow is provided. This

is usually accomplished by establishing a manure pack or providing periodic cleaning along with a ridge vent and open sidewall. Many producers make the mistake of closing up this type of building to try and increase the inside temperature. This usually causes excessively high humidity and increases animal health problems.

Cold buildings can benefit in several ways from insulation. Using insulation with a R-value of 3 or more in the roof or ceiling will modify the temperature of the interior building surface. This will provide two major benefits. First, in the winter, a warmer building surface temperature will reduce condensation. Reducing condensation will increase the life span of the building by reducing corrosion and wood rot. Second, a roof that is kept warmer in the winter will reduce the amount of radiant heat lost from the animal and a cooler roof in the summer will reduce the radiant heat gain. It is important to remember that the small amounts of insulation used to control condensation and radiation will have, at most, a 5 to 10 degree F effect on internal building temperatures. The combined effects of a small change in building temperature along with a reduction in radiant heat gain or loss can result in increased animal comfort and a longer building life span.

WARM HOUSING

Stanchion barns, calf barns, and milking centers are usually classified as warm housing units. In these units, insulation is primarily used to maintain a specified building temperature. For this type of housing, both ceiling and sidewall insulation will be necessary to maintain this temperature.

Underinsulating warm housing units causes excessive heat loss and reduces building temperatures if no supplemental heat is added. This is especially true in northern Illinois barns when cold outside conditions can cause inside temperature to drop below the desired level. When the building is properly insulated, animal heat production can provide all of the heat needed over a wide range of outside temperatures. Reducing ventilation or tightening the building to raise inside temperatures will cause high humidities and health related problems. The dairyman can either add insulation or supplemental heat to raise internal temperatures to the desired levels or allow the inside temperatures to fall to a less than optimal level. The alternative chosen depends upon the cost of adding supplemental heat and/or insulation and the economic effect associated with any decline in livestock feed efficiency and/or production rate.

MECHANICAL VENTILATION

In most warm housing units, a mechanical ventilation system is necessary to provide the careful ventilation control needed to maintain the desired inside temperature. The goal of the mechanical ventilation system is to maintain the desired inside environment as efficiently as possible. Too much ventilation in the winter will remove heat unnecessarily and either result in higher heating bills or a lower inside temperature. Fan efficiencies are also a consideration when high airflow rates are necessary in the summer. The electrical energy required to move ventilation air can vary by more than 200 percent among fans of the

same size with equally-sized motors. As a rule, large diameter fans tend to be more efficient than smaller diameter fans and large fans should be utilized when large amounts of air must be moved. If the animals are not in the building, considerable energy can be saved by turning off the fans. In a 70-cow tie stall operation, 320 dollars per summer was saved when the fans were turned off when the cows were outside (based on 6 cents per kwhr). The proper size, accurate control, and energy efficient operation of mechanical ventilation systems is necessary to effectively maintain the desired inside environment and minimize energy consumption.

NATURAL VENTILATION

Natural ventilation systems offer the dairy farmer a viable alternative to the energy demanding mechanical ventilation systems used today in dairy barns. University of Wisconsin researchers have shown savings of up to 30 kwhr per cow per month when mechanical ventilation systems are converted to natural ventilation systems. At 6 cents per kwhr, this is equal to $1.80 per cow per month in energy savings not to mention additional ownership and maintenance savings.

It is not necessarily true that naturally ventilated buldings are "cold barns." The first naturally ventilated barns were not insulated and therefore were only a few degrees warmer than outside conditions. Many present dairy barns are insulated and ventilated by natural means. Temperatures can be kept well within the comfort range of the animal for the majority of the time when the natural ventilation system is properly designed and managed.

ENERGY QUALITY CONSIDERATIONS

One of the more recent issues to cloud the energy picture is the issue of energy quality. The dairy farmer is a special use customer and has some unique energy requirements that vary considerably from the majority of consumers. The problem occurs when neutral-to-earth voltages reach a high level that affects cow health and milk production. This high neutral-to-earth voltage or "stray voltage" causes a small electric current to flow through the cow's body and can cause adverse side affects.

It is likely that the number of stray voltage problems will increase unless appropriate action is taken. Poor wiring practices, increasing farm size and sophistication, farm wiring deterioration, and increasing rural distribution electric loads may result in higher stray voltage levels. It is the responsibility of the dairyman to insure that the special needs for low stray voltage levels are met to help insure maximum productivity for the dairy enterprise.

Research from the University of Minnesota has shown that, under normal conditions, the milking equipment itself is not a likely path of problem current levels. The measured resistance to current flow from the milkline and claw-to-ground (through the cow) was so high that a 26 volts alternating current on a low line and 47 volts alternating current on a high line would be needed to get a 14 percent response rate from dairy animals. A direct fault from the electrical system to the milkline would be required to obtain these voltage levels.

The more likely path for current flow is from a metal point of contact with the animal to the floor or ground. Metal stalls, stanchions, waterers, and feeders are good conductors of electricity and often come in contact with the cow. The path of current flow would most likely be between one or more of these points of contact and the floor or ground. In cases where two or more different metal objects can be touched simultaneously by the same animal they should be "bonded" by installing a conducting wire between them to provide a good electrical connection. This will insure that all metal objects are at the same voltage and that no current flow can occur. By eliminating current flow between different metal objects the dairyman can concentrate on the current flow between those objects and the ground.

Several areas need to be checked for stray voltage or metal to ground voltage. Areas where milking, feeding, and watering occur are most likely to affect animal health and production when stray voltage levels are high. If these areas cannot be found to show high stray voltage readings, it is not likely that a problem exists.

A method used to monitor and diagnose the potential for stray voltage problems has been developed by the University of Minnesota. Electricians, equipment dealers, and other qualified personnel who are trained in conducting such an audit can be used to diagnose possible problems. Methods are available that reduce the potential for stray voltage problems and the resultant effects to animal health and milk production. Efforts should be made to lower potential stray problems and maximize electrical quality on the farmstead.

IN SUMMARY

Many methods are available to improve energy efficiency on the dairy farm. Many of those methods are found in this publication while other methods are easily found elsewhere. The profit-conscious dairy manager should be aware of those methods and implement them when possible. Energy costs, although smaller than many other expense categories, warrants close attention as the dairy farmer trims the operation for efficiency.

Table 1. Energy Cost Comparisons for Different Fuels.

ENERGY	COST/UNIT	HEAT VALUE	COST PER LOW EFF.1	MILLION BTU HIGH EFF.2
Electricity	$0.06/kwhr	3413 BTU/kwhr	$17.58	$ 9.76
Electricity	0.08	"	23.44	13.02
Electricity	0.10	"	29.30	16.23
Fuel Oil	$0.80/gal	145,000 BTU/gal	6.90	5.81
Fuel Oil	1.00	"	8.62	7.26
Fuel Oil	1.20	"	10.34	8.71
Propane	$0.40/gal	91,700 BTU/gal	5.45	4.59
Propane	0.60	"	8.18	6.89
Propane	0.80	"	10.91	9.18
Natural Gas	$0.40/100ft	1,000 BTU/ft	5.00	4.21
Natural Gas	0.60	"	7.50	6.32
Natural Gas	0.80	"	10.00	8.42

1Assumes efficiency of: 100% for electricity; 80% for indirect fired propane, natural gas, and fuel oil.

2Assumes efficiency of: 1.8 COP for electric heat pump; 95% for direct fired propane and natural gas.

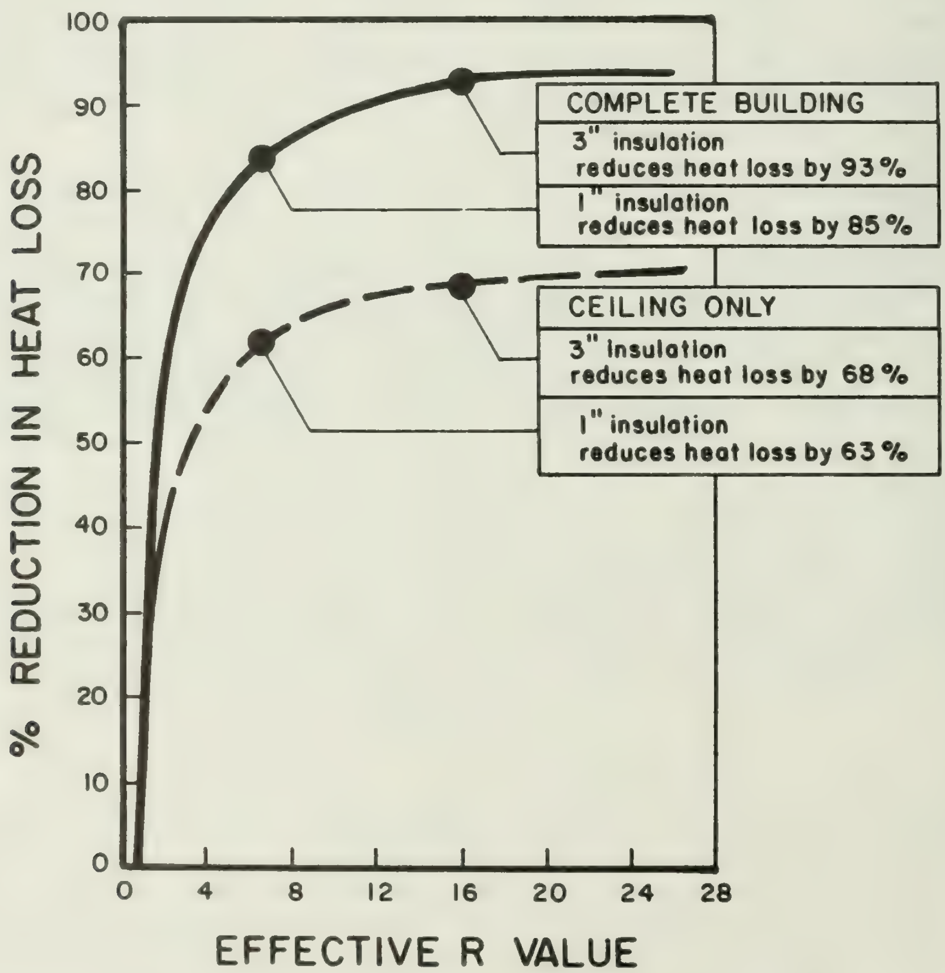


Figure 1. Comparison of Percent Heat Saved When Insulating Ceiling Only or Complete Building With 1 and 3 Inches of Expanded Polystyrene Insulation.

University of Illinois
Research Reports

Involution of the Mammary Gland

Walter L. Hurley

Your records show that three cows should be dried-off today to give them the recommended 45-50 days of dry period before their predicted calving date. But you really do not have time to fool with them today. You would have to dry-cow treat them, then transfer them to the dry-cow lot. A couple of them are still milking pretty good, anyway, and what is the big deal with 45-50 days dry period? Those recommendations are only estimates, right? And, they have not shown any mastitis problems, so maybe they do not need dry-cow antibiotic treatment after all. Once they are in the dry lot, they will just get hay and silage and pretty much be ignored until calving approaches. They are dry, and dry-cows do not put milk in the pail.

Well, those recommendations for length of the dry period come from a number of studies which consistently show that a cow must have at least 40 days dry period for production in the subsequent lactation to reach expected levels. A dry period longer than about 60 days is economically wasteful, because that is just that much longer she is not paying her way. And, the dry-cow antibiotic treatment, aside from teat-dipping with disinfectant during lactation, is probably the major successful method for controlling mastitis that is available.

But looking at the cow, except for a little swelling for a few days after the last milking, there does not seem to be much happening in that udder, right? Actually, at the tissue and cellular levels, many active and organized changes are occurring. Many of those changes may be at the heart of the biological reasons behind the management recommendations for dry cows. Unlike the lactating mammary gland which has been studied intensively, an understanding of the "dry" udder generally has been lacking. What the "dry" or nonlactating mammary gland is doing and how it gets from a lactating to a nonlactating state are some of the questions we currently are studying. The answers to those questions bear upon such important aspects of dairy cattle management as why the very early dry period is a time of increased susceptibility to mastitis, and why the 45-50 day dry period is optimal.

From a cellular viewpoint, the lactating mammary gland is an extreme of nature. Even at the tail-end of her lactation the cells that are producing milk are synthesizing and secreting massive amounts of milk components including milk sugars (especially lactose), milk proteins (caseins, alpha-lactalbumin, beta-lactoglobulin), and milk fat. What happens to the synthesis of these milk components and what

other functions do the mammary cells have during involution of the mammary gland? Like the composition of milk, the composition of secretions from the involuting gland can give some clues of what changes are occurring in the mammary cells. If you were to take a sample from the udder at 12 hours after the last milking, little change in composition would have occurred. It would be essentially like milk, which makes sense because you normally milk cows at about 12 hour intervals. However, if you waited until 24 hours after the last milking, the composition already will have begun to change. By day 3 of the dry period the composition of the fluid in the gland will have changed substantially, and by one week the compositional changes are in full swing.

Although total fluid volume increases for a few days after the last milking because you are no longer removing the milk, by day 6 or 7 of the dry period the volume is down to where it was before she was dried-off. Thereafter, it continues to decline. Of the major components of milk, lactose declines in concentration the most rapidly. This makes sense because milk is 88 percent water and lactose is the primary component responsible for drawing the water from the blood into the newly synthesized milk. If you want to shut down milk production, the quickest way is to shut down lactose synthesis. Milk fat declines but is somewhat variable in the rate of decline. The major milk proteins, casein, alpha-lactalbumin and beta-lactoglobulin, actually increase slightly or stay the same in concentration for a few days, then are declining by one week into the dry period. In contrast, total protein in the secretion is increasing in early involution, and increases even more later in involution. This increased total protein is caused by an increased entry of serum proteins (immunoglobulins and serum albumin) into the secretion. Also, several other proteins that normally are very low in milk increase dramatically during involution. Two of those proteins of particular interest are lactoferrin and the enzyme, n-acetyl-beta-D-glucosaminidase (NAGase). Leukocyte cells, primarily phagocytes, enter into the gland in large numbers in early involution with polymorphonuclear leukocytes (PMN) predominating in the first few days, followed by a proportional increase in macrophages.

If we focus on the first week of involution, it quickly becomes understandable why there is an acute increase in the susceptibility of the udder to infection. The udder is in a difficult transition state from lactation to nonlactation. The cards are stacked against her during this period and in favor of any invading bacteria. Milk is no longer being routinely removed, and milk is a great growth medium for bacteria. Almost all of the cow's defenses are compromised during that week after drying off. Bacteria require iron to grow. Iron is bound by the protein, lactoferrin, and becomes unavailable for use by the bacteria. This makes lactoferrin bacteriostatic. However, lactoferrin is relatively low in early involution. To make matters worse, citrate is still high. Citrate is a nonprotein product of milk synthesis, but also will bind iron. The difference is that bacteria can use citrate-

bound iron. So, in the first few days of the dry period, the ratio of citrate to lactoferrin is very high and in the favor of bacterial growth.

The effectiveness of the phagocytic leukocytes that invade the gland is compromised during early involution. The numbers of leukocytes are still relatively low, although increasing, during the first few critical days of involution, and we have found their viability (the percent live cells) to be depressed. In addition, because there are so many milk fat globules and casein micelles (casein aggregates) in the secretions, the phagocytic leukocytes are busy ingesting those compared to the relatively few bacteria that might be present. There is some evidence that the mammary environment is detrimental to the bacterial killing capacity of phagocytic leukocytes.

By the second week of involution, most of these negative factors have changed in favor of the cow. Lactoferrin has increased substantially, while citrate has declined, and the iron in the secretion is relatively unavailable to bacteria. Much of the milk fat and casein have been removed so that the large numbers of phagocytic cells can more efficiently deal with a bacterial challenge to the udder. Immunoglobulins have increased, and these may have a role in preventing infection during later involution.

It is small wonder that the first week of the dry period is so critical in terms of susceptibility to infection. And it should be clear why dry-cow antibiotic treatment has been one of the major contributions to controlling mastitis. Such antibiotic treatment helps her get through that transition period until the udder can take care of itself when challenged by bacteria. In fact, the gland during the mid-dry period is relatively immune to infection. If an infection begins during that time, usually the cow's own defenses will eliminate it easily.

What do the changes in secretion composition tell us about the activities of mammary tissue during involution. Obviously, the synthesis of milk components decreases. But the concentrations of the milk components (lactose, milk fat and milk proteins) never reaches zero. There is always some there, suggesting that there continues to be a low level of synthesis of milk components during the dry period. In contrast, proteins like lactoferrin and NAGase that are low during lactation, are synthesized and secreted in relatively large amounts during involution. The tissue has simply changed functions, not gone "dry". In addition to being bacteriostatic, lactoferrin has effects on the cells of the immune system and those functions may be as important in the involuting mammary gland as the iron binding function. That is an area which remains relatively unexplored for the cow. Certainly lactoferrin is of key interest in the function and defense of the udder during the dry period. The function of the large concentrations of NAGase in the gland is not known. NAGase levels often are associated

with numbers of leukocytes in milk. High leukocytes numbers (somatic cell counts), as during mastitis, generally are accompanied by increased milk NAGase levels. But, most of the NAGase in the secretion arises from the mammary secretory cells and not from the leukocytes. While the function of NAGase in the gland is unknown, the large increases in concentration of the enzyme again attest to the altered function of the mammary tissue.

Does any of this have anything to do with why 45 to 50 days dry is optimal for subsequent milk production? Although we cannot yet put our finger precisely on how, the answer is certainly yes. As will be discussed further in the accompanying paper, it seems that once the process of involution is initiated it must go through the entire process before the gland can be restimulated with maximum effect. Currently, we are trying to define more clearly what the process of involution is at the cellular level. This is necessary before we can effectively ask how the process of involution is affecting subsequent redevelopment of the gland and reinitiation of lactation at the next calving.

Histological Observations of the Mammary Gland During Involution

Walter L. Hurley

What occurs at the tissue and cellular levels during the process of mammary involution? As discussed in the previous paper, changes in the composition of mammary secretions suggest that changes in cell function occur. But, the composition of secretions only tells part of the story. We have done histological and electron microscope studies on involuting mammary tissue and find some very dramatic changes in the cells of the udder.

To review the histology of mammary tissue, the milk secreting units are multicellular structures called alveoli. They have a single layer of epithelial cells surrounding the alveolar lumen. It is these epithelial cells that synthesize and secrete milk into the alveolar lumen. On the basal side of the alveolar epithelial cells (opposite end from the lumenal end) are myoepithelial cells which have long appendages that form a basket-like network around the alveolus (not seen in the figure). These are the cells that contract in response to oxytocin. The oxytocin is released from the pituitary gland (at the base of the brain) in response to manual stimulation of the udder such as preparing the udder for milking or nursing of the calf. Around the basal side of the whole alveolus (epithelial and myoepithelial cells) is a connective tissue membrane called the basement membrane which helps anchor the cells. Between alveoli is the stromal or interalveolar area in which are connective tissue fibers and several cell types which do not secrete milk.

During lactation, the alveolar epithelial cells show signs of secreting milk (Fig. 1A). Small vesicles (containing protein or milk fat droplets) are readily apparent. However, by day 2 of involution (Fig. 1B), many alveolar epithelial cells have large vacuoles. By day 4 of involution, few small vesicles can be found and most alveolar cells contain one or two large vacuoles (day 7 shown in Fig. 1C). At the electron microscope level, these vacuoles are filled with milk protein (casein micelles) and/or milk fat. The vacuoles occupy most of the intracellular space and force the nucleus to the basal end of the cell. The vacuoles remain the predominant feature until about the third week of the dry period when they disappear. They probably form by coalescing of the small secretory vesicles and milk fat droplets when the mechanism of secretion of those components from the cell breaks down in early involution. The cell may not be able to get rid of the milk components it has synthesized and they accumulate in the large vacuoles. Specifically how they are formed and how they are eliminated from the cells are under investigation.

The interalveolar or stromal tissue increases as the alveoli shrink. By three to four weeks of the dry period (Fig. 1D), many alveoli appear as a solid mass of cells or at least as multiple layers of cells around a small lumen. No milk secreting vesicles are seen. Cells in the interalveolar tissue (Fig. 1A and C) probably are plasma cells (secreting some types of immunoglobulin), fibroblasts (synthesizing the fibrous connective tissue), or invading leukocytes (also seen in the lumen of alveoli in Fig. 1C).

Ultrastructural studies indicate that many of the components necessary for cellular metabolism and synthesis of proteins remain in the involuting cells, although at a much reduced level. Interestingly, few lysosomes are present in the involuting alveolar cells in the cow. Lysosomes are subcellular organelles containing many hydrolytic enzymes. When cells degrade they form lysosomes, the components of which are involved in digesting cellular material (a process called autophagocytosis). Not only are few lysosomes formed in cells of the cow, but there is little evidence of cellular damage or sloughing of the alveolar cells from the basement membrane. This is in contrast to the rat and other rodent species where involution of the mammary gland includes autophagocytosis and loss of alveolar epithelial cells. Until recently it has been assumed that the cow's udder involuted like the rat mammary gland. We and others currently are finding that involution in the cow is an orderly process with little or no loss of tissue.

How do these kinds of tissue structure studies relate to management of the dairy cow? Firstly, it suggests an explanation for why you can not skip milkings without losing productivity. We have observed that many of the changes in mammary function which occur in early involution are occurring between about 36 and 48 hours after the last milking. Some changes may begin by 24 hours. Skip one milking and the process of involution already has begun in at least some of the alveoli in the udder. Not all alveoli will involute at the same rate and the cow will still give milk, but not optimally.

This raises another question. Once an alveolar cell has begun this process of involution, can it go back to a lactating state or when can it go back? This is an important question which requires a better understanding of involution process before it can be answered. At this time we only can make some general observations. We need to make two assumptions: 1) that a cell must proceed completely through the process of involution before it can be maximally stimulated to redevelop and lactate optimally at the next calving, and 2) that most of the redevelopment of the gland leading up to colostrum formation and initiation of lactation occurs in the last three to four weeks prior to calving. From our ultrastructural work it seems unlikely that significant redevelopment or reinitiation of milk secretion could occur in the cells until the large vacuoles are gone. That process takes about three weeks. Add three or four weeks for redevelopment of the tissue then a minimum dry period would be six to seven weeks or around

45 days. Tack on a few days margin for her to potentially calve early and a dry period of 45 to 50 days should be optimum. This is the dry period length that repeatedly has been shown as optimum. Anything less than 40 days dry is suboptimal. This may be caused by the overlapping of the involuting phase with the redevelopment phase. Some of the mammary cells do not complete the process of involution before they are stimulated to redevelop by the impending parturition. Anything longer than 60 days is just increasing the time the mammary tissue is in a "steady state" phase of involution until the next round of redevelopment. It also is increasing the time she is idle and not paying her way.

We are only beginning to define the changes in mammary function that occur during involution. The mammary tissue of the dairy cow is always functioning, whether it is in a lactating state, a nonlactating state, or a transition state between lactating and nonlactating. Our ultimate goal is to understand what occurs in those transition states and how the function of nonlactating mammary tissue relates to the function of lactating tissue.

FIGURE LEGENDS

Fig. 1A - Light microscopy of lactating bovine mammary tissue. Alveolar structures have the lumen (L) surrounded by a single layer of milk secreting epithelial cells (E). Epithelial cells contain numerous secretory vesicles (v) filled with milk constituents in the process of being secreted into the lumen. B - blood vessel; S - stromal cells.

Fig. 1B - Light microscopy of mammary tissue on day 2 of involution. Note the large vacuoles (V) in the secretory cells. L - lumen.

Fig. 1C - Light microscopy of mammary tissue on day 7 of involution. Large vacuoles (V) persist. Phagocytic leukocytes often are observed in the lumen of alveoli (Ma - macrophage). Stromal area between alveoli has increased. S - stromal cells.

Fig. 1D - Light microscopy of mammary tissue on day 30 of involution. Many alveoli have collapsed into a solid ball of cells (arrow). Stromal area is greatly increased compared to lactating tissue. Large vacuoles are not evident in epithelial cells.

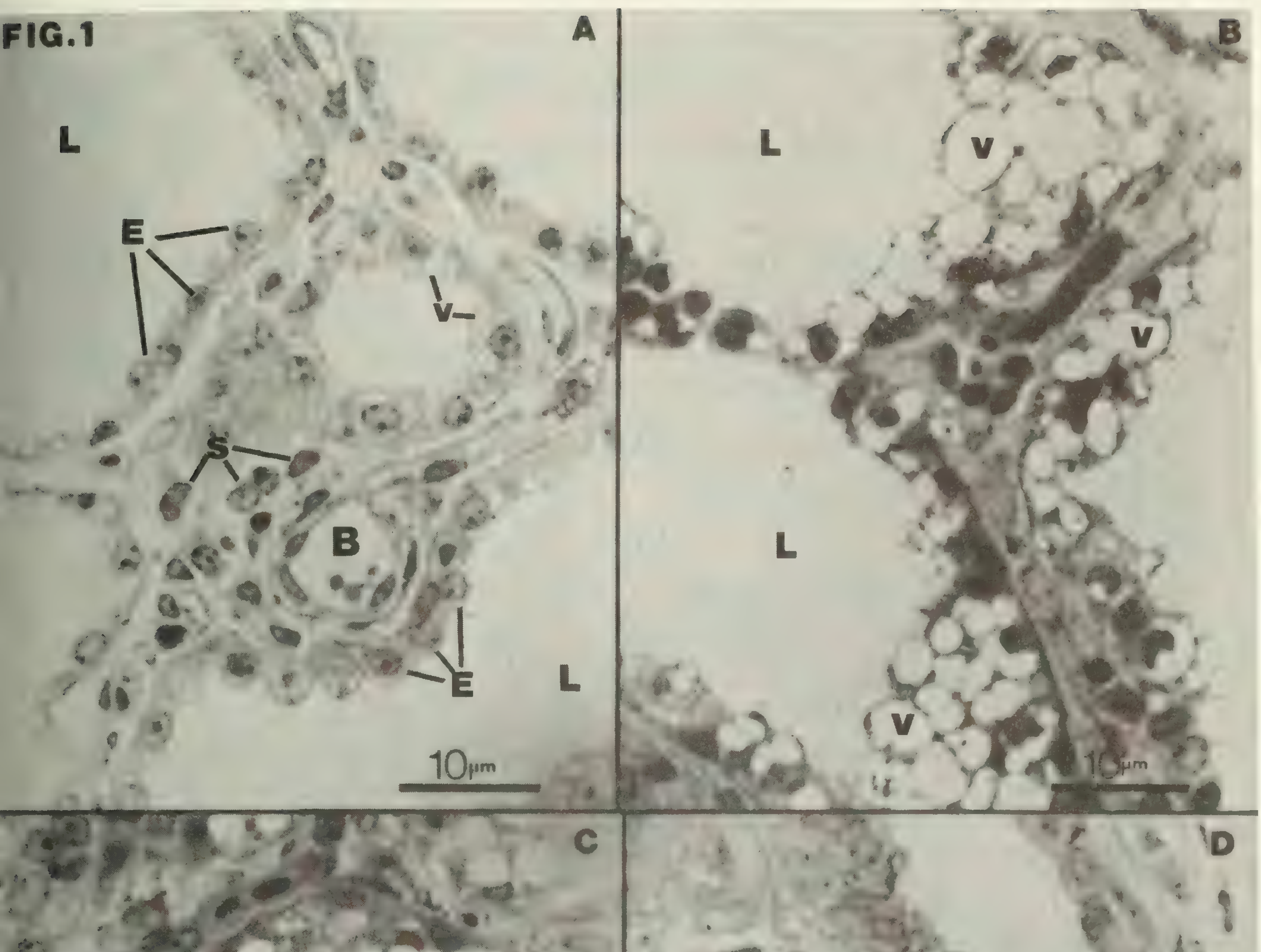


FIG.1
A
L
E
V
S
B
E
L
10µm
B
L
V
V
L
V
10µm
C
V
V
Ma
V
S
10µm
D
10µm

Do Two-Year-Olds Burn Out?

Roger D. Shanks and Mary A. Greiner

"Burn-out" is a subjective classification used as a reason to cull dairy cows after an overly productive first lactation. Since studies show that the majority of dairy cows complete three or more lactations, this suggests that two-year olds do not exhibit burn-out. To better evaluate the existence of "burn-out", let us look more closely at three situations. 1) Why are cows removed from dairy herds? 2) How are lactation curves of two-year olds different from those of older cows? 3) What is effect of first-lactation production on herd life and later production?

DISPOSAL REASONS

Low production and unsatisfactory reproductive performance are the major reasons for removal when cows are not sold for dairy purposes. Neither of these reasons should be interpreted as resulting from "burn-out".

Ohio researchers summarized variations in disposal reasons with age, for 8722 females removed from 12 institutional herds 1933 to 1972. Proportionately, most removals due to reproduction occurred during 25 to 36 months, most removals for low production during 37 to 48 months, most removals due to milking characteristics (temperament, hard milker, low persistency, other) during 49 to 60 months, most removals for mastitis during 61 to 72 months, and most removals for general health occurred after 10 years of age.

Undesirable type was reported as the most frequent secondary reason for culling during the age interval 6 to 36 months. After 36 months, type ranked third behind removals for reproductive causes and low production. Possibly this secondary disposal reason for undesirable type represents two-year old burn-out.

Canadian researchers found similar reasons for disposal of 19,336 Holstein cows in 1967 and 1968. Cows sold for dairy purposes were 25.8 percent of all cows; 9.4 percent of all cows died on the farm; 20.8 percent were sold because they had breeding problems; 15.5 percent were slaughtered because of low production; and 10.2 percent were slaughtered because of udder problems. Diseases, chiefly mastitis, contributed to the slaughter of 6.9 percent of all cows. Feet and leg problems accounted for 2.8 percent of slaughterings, whereas undefined reasons accounted for 4.0 percent of all cattle sold for beef.

Breeding problems, low production, and udder diseases are the main reasons dairy cows are slaughtered. These Canadian researchers also found that reasons for disposal differ from lactation to lactation. The

main trends are decline in percentage of cows sold for dairy purposes with increasing age, decline in percentage of cows culled for low production from first to third lactation, and increases in reproductive, udder, and disease problems. Some cows leave herds as a result of lack of soundness, but the percentage is very low in early lactations.

LACTATION CURVES

Lactation curves of cows in their first lactation are much different than lactation curves of later lactations. Two-year olds have lower peak production, take longer to reach peak and in general are more persistent than older cows in later lactations. However, variation in persistency is also greater in first lactation.

A cow is considered persistent if she produces about the same amount of milk each month. This could result in high or low annual production depending on the level of average daily production. But, what does it mean that variation in persistency is greater in first lactation? First lactation cows differ greatly in persistency. The cows which give more, or the same amount of milk each month throughout lactation are highly persistent. The cows which exhibit a rapid decline in milk yield following peak yield have poor persistence. Most cows increase in daily production to peak yield during their second or third month and then gradually decline in daily yield thereafter. The greater variability in persistency of first lactation occurs because more cows in first lactation are either highly or poorly persistent, rather than fitting the normal pattern, as occurs more often in later lactations.

Some may consider that peak daily yield of two-year olds should be limited because they "burn-out". A precipitous decline in daily yield following peak yield would signify "burn-out". Phenotypically (genetics and environment combined), this precipitous decline was not found in a sample of 35,764 first lactations from California herds. The association between peak yield and persistency was near zero. Genetically, there was less evidence of "burn-out" because a slight positive association (correlation of .38 in Table 1) was found between 305-day mature equivalent milk yield and persistency. The sires with high average daughter milk superiority averaged more persistency in their daughters, and the sires with low milk yields in their daughters averaged less persistency in their daughters. Also, changes in peak yield were not closely associated with changes in persistency, either phenotypically or genetically. In other words, some cows with high peak yields were persistent while others with high peak yield were not very persistent. In either case, cows with high peak yields gave the most milk annually (correlations of .74 and .87 in Table 1); therefore, they are the best two-year olds for milk yield.

Selection towards increases in 305-day mature equivalent milk yield would be expected to reduce persistency slightly and to greatly increase peak yield. Increases in peak yield should not be considered detrimental, because the evidence implies that this leads to high annual yield.

HERD LIFE

A report from Pennsylvania evaluated the effect of first-lactation milk yield on herd life and later production. First lactation cows were grouped by milk yield into eleven groups. The top six groups completed 3.45 to 3.65 lactations while the lower five groups completed 2.74 to 3.44 lactations. Higher producing cows stayed in the herd longer with the highest producing group of cows in first lactation being the highest producing group in third, fourth, and fifth lactations. In second lactation, the highest producing group was the second highest producing group from first lactation, exceeding the top group from first lactation by 40 pounds. The lower nine groups ranked the same in both first and second lactations and all eleven groups ranked the same for production in first, third and fourth lactations. Although the group rankings were highly consistent, the production in the later lactations was regressed toward the average and consequently, the difference between high and low producing groups was reduced in later lactation. For example, the mature equivalent production of the high group in later lactations was 2400 to 2900 pounds below the mature equivalent production in first lactation. The low producing group in first lactation increased over 2200 pounds in mature equivalent production in later lactations. But, the low producing group in first lactation had the lowest production in all subsequent lactations.

CONCLUSION

Some two-year olds may burn-out, but herdlife is shortened more often by low production and breeding problems. High producing cows in first lactation continue to be high producing in later lactations.

Table 1. Phenotypic and Genetic Correlations of 305-Day Mature Equivalent (ME) Milk Yield with Peak Yield, Week of Peak Yield, and Persistency of 35,764 First Lactations.

	First lactation 305-day ME milk yield	
	Phenotypic correlation	Genetic correlation
Peak yield	.74	.87
Week of peak yield	.08	.81
Persistency	.03	.38

Effect of Physical Form of the Diet on Dairy Cows in Early Lactation

Steven T. Woodford and Michael R. Murphy

The trend in dairy rations over the last 20 years has been to reduce the quantity and particle size of forage in the diet. Widespread use of concentrate-rich feeds, low in "effective fiber," has introduced nutritional and metabolic problems.

Effective fiber is considered to be any forage that stimulates rumination. The primary benefit of effective fiber is that it increases saliva production because of its close association with time spent chewing. Saliva is a natural buffer of the rumen and affects rumen pH, the ratio of acetate to propionate, milk fat percentage, and the passage of digesta from the rumen. Excessive quantities of effective fiber in the diet may reduce intake due to the extended time required for breakdown and passage of long fiber particles out of the rumen. The objective of this study was to determine the quantity of effective fiber needed to maximize intake and production of early lactation dairy cows.

Forty-two Holstein cows (9 ruminally cannulated) were assigned 14 days postpartum to one of three diets: A) 60% concentrate and 40% alfalfa haylage; B) 60% concentrate, 28% alfalfa haylage and 12% alfalfa pellets; or C) 60% concentrate, 12% alfalfa haylage and 28% alfalfa pellets. All feed proportions were expressed on a dry matter basis. Diets were similar in protein (17% crude protein) and fiber (27.4-28.6% neutral detergent fiber (NDF), 18.0-19.3% acid detergent fiber) but differed in their effective fiber content. The trial lasted for 12 weeks.

Dry matter intake and milk production were recorded daily. Milk composition and body weight were measured weekly. During the 4th, 8th, and 12th week postpartum, the following measures were made. Chewing activity of all cows was recorded by visual observation every 5 minutes for 24 hours. Ruminal fluid samples were taken from the cannulated cows every 2 hours for 24 hours, for measurement of pH, pattern of fermentation and ruminal fluid outflow. Apparent digestibilities of the diets were determined using 15 cows.

Table 1 contains dry matter intake and milk production results. Cows fed diet C exhibited marked depressions in dry matter intake, milk and fat-corrected milk production, and milk fat percentage compared to cows fed diets A or B. Cows on diet B had the highest milk and 4% fat-corrected milk production.

Level of dietary effective fiber greatly influenced chewing behavior and the rumen environment. Total chewing time was reduced 4.5 hours when haylage was reduced from 40% (Diet A) to 12% (Diet C) of total diet dry matter (Table 2). Decreased saliva production associated with reduced chewing activity was evidenced by the lower volume of fluid moving through the rumen on diet C compared to diet A. As haylage content of the diet decreased, so did rumen pH, an indication of increased rumen acidosis. Lower rumen pH in cows fed diet C may, in part, have been responsible for lower apparent digestibilities of dry matter and NDF.

These results strongly suggest that dairy cows in early lactation require a minimum level of dietary effective fiber to achieve maximum dry matter intake and milk production. Because total time spent chewing is closely related to the level of forage in a diet, time spent chewing may be helpful in assessing the effective fiber content of diets fed to lactating dairy cattle.

Table 1. Dry Matter Intake and Milk Production

Diet	Dry matter intake, lb/d	Dry matter intake, % of body wt	Milk production, lb/d	Milk fat, %	4% fat corrected milk, lb/d
A	51.0	3.76	74.1	3.01	63.4
B	50.8	3.99	78.1	2.93	65.3
C	41.4	3.14	55.7	2.59	55.7

Table 2. Chewing Time, Ruminal Fluid Outflow and Apparent Digestibility.

Diet	Total chewing, hours/d	Ruminal fluid, outflow, gal/d	Ruminal fluid, pH	Apparent Digestibility, %, Dry matter	Apparent Digestibility, %, Neutral detergent fiber
A	10.8	64	5.89	63.9	31.6
B	9.4	51	5.73	64.5	37.0
C	6.3	36	5.63	59.2	23.4

Milk Replacers Containing Acidified Soy Proteins

Peter S. Erickson, Daniel J. Schauff, Michael R. Murphy, and Carl L. Davis

Acidified milk replacers, developed as a by-product of the Gouda cheese industry in the Netherlands, have been used in Europe for many years. Acidification of milk replacers containing soy proteins has not been extensively researched. Milk replacers containing soy protein have not competed well with conventional whey protein or whole milk replacers. In theory, acidification may aid digestion of soy protein, reduce growth of pathogenic organisms, increase intake by encouraging smaller but more frequent meals, and enhance preservability of mixed replacer.

The objectives of this study were to compare digestibility (Experiment 1) and growth (Experiment 2) of calves fed replacers containing soy protein concentrate that had been acidified or left untreated. Another trial (Experiment 3) was conducted to compare growth of calves fed these replacers with that of calves fed a conventional replacer containing whey proteins.

In the first study, digestibility of replacers was measured in six Holstein bull calves (5 weeks old) fed at 10 percent of body weight per day. Calves were fed twice daily with water available at all times. In the second experiment, 20 Holstein bull calves (approximately 1 week old) were offered replacers four times a day at 20 percent of body weight per day . The latter was designed to mimic ad libitum feeding of whey based replacers reported by Woodford and associates in the 1986 Illinois Dairy Report. Calves remained on the diets for 28 days. Body weight, wither height, and heart girth were measured weekly and intakes adjusted weekly to compensate for weight gain. In the third trial, 21 Holstein bull calves (approximately 1 week old) were fed either replacer containing soy protein or one containing whey protein at 10 percent of body weight per day. Growth was measured and intake adjusted, as in the second study. All replacers contained 21 to 26 percent crude protein and were fed at 12.5 percent dry matter.

Results of the first experiment (Table 1) indicated that calves apparently digested similar amounts of dry matter and crude protein; however, a higher proportion of absorbed nitrogen was retained by calves fed the acidified replacer containing soy protein. In contrast, growth of calves offered these replacers at 20 percent of body weight per day (Experiment 2) showed that acidification adversely affected performance (Table 2). When fed at 10 percent of body weight

per day (Experiment 3), growth was not affected by acidification or the presence of soy protein (Table 3). The fact that relatively large amounts of feed were required per pound of gain may indicate that an environmental interaction was present in all three experiments.

Acidification of replacer containing soy protein was not beneficial at high levels of intake; however, calves fed the replacers containing soy protein performed as well as those being fed a conventional whey-based replacer when fed at 10 percent of body weight per day.

Table 1. Nutrient Intake, Digestibility, and Nitrogen Retention in Calves Fed Acidified or Untreated Soy Protein Containing Replacers

	Replacer	
Measure	Acidified	Untreated
Dry matter intake, lb/d	1.5	1.2
Nutrient digestibility		
Dry matter, %	92.	91.
Fat, %	95.	92.
Crude Protein, %	88.	86.
Nitrogen retained as percentage of that absorbed	52.	36.

Table 2. Dry Matter Intake and Growth of Calves Fed Acidified or Untreated Soy Protein Replacers at 20 Percent of Body Weight

Variable	Replacer: Acidified	Replacer: Untreated
Dry matter intake, lb/d	1.9	2.3
Intake, % of offered	73.	82.
Gain, lb/d	.6	1.1
Girth gain, in/week	.5	.8
Height gain, in/week	.2	.3
Feed efficiency (lb feed dry matter/lb gain)	3.3	2.3

Table 3. Dry Matter Intake and Growth of Calves Fed Acidified or Untreated Soy Protein Milk Replacer or Conventional Whey Protein Replacer

Measure	Replacer: Acidified Soy	Replacer: Untreated Soy	Replacer: Whey
Dry matter Intake, lb/d	1.2	1.2	1.3
Intake, % of offered	99.	95.	100.
Gain, lb/d	.4	.2	.3
Girth gain, in/week	.3	.3	.2
Height gain, in/week	.2	.2	.3
Feed efficiency, lb feed dry matter/lb gain	3.2	5.0	4.0

Effects of Growth Rate of Heifers on Reproduction and Lactation

Carl L. Davis

Probably the most neglected group of animals in any dairy herd is the replacement heifers. Nutritionally, far less attention is paid to this group of animals because they have survived the critical phase of early calfhood and are a long way from becoming productive members of the herd. More information is accumulating which points to the fact that if we expect these heifers to produce up to their genetic ability, we must pay more attention to them especially during the period from 3 months of age until they are bred at 15 to 18 months. This is the most critical time in the development of the milk synthesizing tissue and the amount of this tissue present can be greatly affected by the nutrition of the animal.

The overall goal of the dairymanager should be to rear the heifer in such a manner that she reaches puberty (first heat) at about 9 to 11 months of age and that she attain sufficient size (775-800 pounds for large breeds) to be bred at 15 months of age. Since the main factor affecting the appearance of first heat is body weight and not age (Table 1), the rate of body weight gain from 3 months to 10 months of age should be in the range of 1.5 to 1.8 lbs per day in order to have the heifer attain a weight of 550-600 pounds at the sign of first heat. Growth rates which are grossly outside of this range (either under or over) can result in a decrease in productive performance.

Effects of Underfeeding

Underfeeding the growing heifer delays the time of first estrus and extends the time required for the animal to reach the desired size for breeding. Breeding at a lower body weight will result in a higher incidence of calving problems and milk yield will be lower during the first lactation due to the extra need of nutrients for growth taking away from milk production.

Effects of Overfeeding

Overfeeding the heifer may be more detrimental to the productive life of the animal than underfeeding. Heifers which have been fed to gain in excess of 1.8 pounds per day from 3 to 12 months of age produce much less milk than herd mates which have been fed to gain 1.5 to 1.8 pounds per day. The most startling finding in the studies reported on the effects of overfeeding is that the overconditioned heifer produced less milk not only in the first lactation but in every

subsequent lactation. Thus, the damage caused by overfeeding is permenant and can not be rectified. This point is clearly evident in the data presented in Table 2. Although the gains in body weight for the restricted fed heifers given in the table are lower than recommended (1.5 pounds/day), it is possible to over come the negative effects of a limited degree of underfeeding by feeding liberally during pregnancy and the first lactation which was the case in this study.

Causes for Reduced Milk Production Due to Overfeeding

It has long been known that the mammary gland starts to develop in the fetal stage of the calf. From birth up to approximately 3 months of age, the mammary gland grows at roughly the same rate as the rest of the body. However, from 3 months of age until about 12 months the mammary gland grows at a rate faster than the body proper. It is during this time period that the gland is subject to outside influences such as overfeeding. To put it simply, the udder becomes overly fat which limits the space for the development of milk secreting tissue. Data in Table 3 illustrates this point. Note that these heifers were 7 months old before the experiment was started but the data show that overfeeding resulted in less milk secreting tissue and more fat tissue. When the same type of experiment was carried out with older heifers (beyond 12 months of age), it was found that overfeeding had essentially no effect on the amount of secretory tissue present in the udder. From these and other studies, we conclude that overfeeding reduces the amount of secretory tissue in the udder if it occurs between 3 and 12 months of age.

In looking deeper into this problem, it has been shown that overfeeding reduces the level of growth hormone in the blood. This hormone has long been known to stimulate the growth of mammary secretory tissue. Recent work with sheep in which ewe lambs were given either a low energy diet, high energy diet, or high energy diet plus injections of growth hormone, over a period of 8 to 20 weeks of age, show that high energy intakes reduces mammary development, but it can be overcome with growth hormone injections (see Table 4). This finding lends further support to the suggestion that overfeeding supresses growth hormone levels which in turn reduces the amount of secretory tissue in the gland.

Summary

1. Both underfeeding and overfeeding of heifers can lead to reduced milk production.
2. The recommended rate of gain is between 1.5 to 1.8 pounds per day.
3. The most critical period with regard to overfeeding is from 3 to 12 months of age.
4. Overfeeding during this time period suppresses the level of growth hormone in the blood, a factor which is essential for the development of the milk synthesizing tissue.

Table 1. Effect of Level of Energy Intake on Age and Weight of Holstein Heifers at First Estrus. (Adapted from Reid et al., Cornell Agric. Expt. Sta. Bull. 897, 1964).

Level of feeding[1]	Age (months)	Weight (lbs)
Low	20.2	634
Medium	11.2	581
High	9.2	612

[1] Refers to energy intake.

Table 2. Effect of Rate of Body Weight Gain of Dairy Heifers on Subsequent Milk Production. (Adapted from Little and Kay, Anim. Prod. 29:121, 1979).

Parameter	Restricted feeding	Ad libitum feeding
Ave. daily gains in body weight (lbs):		
from 3.3 to 9.1 months of age	1.30	2.17
from 9.1 to 15.0 months of age	1.10	1.83
Age at first calving (months)	27.7	28.3
Milk yield (lbs)		
1st lactation	6,299	5,390
2nd lactation	10,327	7,075
3rd lactation	10,589	7,282
TOTAL	27,215	19,747

Table 3. Effect of Plane of Nutrition of Holstein Heifers on Mammary Gland Development. (Adapted from Serjreen et al., J. Dairy Sci. 65:793, 1982).

Measure	Plane of Nutrition: Restricted feeding	Plane of Nutrition: Ad libitum feeding
Age at start (months)	7.4	7.0
Age at first estrus (months)	10.8	9.7
Age at slaughter (months)	14.9	10.9
Body weight at start (lbs)	396.0	378.0
Body weight at end (lbs)*	704.0	706.0
Ave. daily gain (lbs)	1.4	2.8
Total weight of mammary gland (lbs)	3.7	4.9
percent secretory tissue	38.0	22.0
percent fat tissue	62.0	78.0

*Both groups slaughtered at same body weight.

Table 4. Effect of Level of Energy Intake and Growth Hormone Injections on Mammary Development in Sheep. (Adapted from Johnson and Hart, Anim. Prod. 38:253, 1984).

	Relative energy intake from 8 to 20 weeks of age		
	Low	High	High
	Treatments		
Measure	-GH	-GH	+GH
Ave. daily gain (lbs)	0.34	0.63	0.76
Body weight at 20 weeks (lbs)	71.7	92.0	102.5
Relative amount* of secretory tissue with low energy group set at 100	100	87	130

*Using Deoxyribonucleic acid (DNA) as a measure of mammary secretory tissue.

Feeding Fat to Dairy Cows

Carl L. Davis

As the level of milk production continues to increase in our cows, it will become more difficult to meet their nutritional needs. We have reached a point now with our best cows where grain feeding is at the recommended maximum level and yet these cows remain in an energy deficit for long periods of time after calving. Higher levels of grain in the ration (above 60 percent of total ration dry matter) only leads to more problems such as rumen acidosis, reduced fiber digestion, lowered feed intake, more frequent off-feed problems, and lowered fat tests. We need a feeding system where rumen function can be maintained by keeping ample forage in the ration and at the same time boosting the energy density of the grain mix so that we maximize energy intake. Replacing a portion of the cereal grains in the diet with fat appears to be an acceptable approach, since fats contain approximately 2.25 times more energy than do carbohydrates (starches and sugars). There are a number of questions which must be dealt with in deciding whether to feed fat or not.

Should all cows receive the fat supplemented ration?

No. Animals producing less than 60 pounds of milk per day are not likely to respond to additional energy in their ration unless they are presently receiving a poor quality ration in restricted amounts. The cows which are most likely to respond to a fat supplemented ration are those in early lactation (from freshening to 20 weeks into lactation). Data presented in Table 1 points-up that cows which fall in the high and medium production groups remained in a negative energy balance for long periods of time (up to 21 weeks post calving). These are the cows which would benefit most.

Are all fat sources the same?

No. Not all fats are suitable feed sources for milking cows. Free oils (such as corn oil, soybean oil, or sunflower oil) should not be used because they have a negative effect upon the rumen fermentation resulting in reduced fiber digestion which leads to lower fat tests. It is important to select a fat source which is "inert" in the rumen (it does not significantly alter the rumen fermentation). A list of acceptable fat sources are provided in Table 2 along with recommended amounts to feed. Calcium salts of fatty acids and prilled fat products will soon be marketed for the purpose of adding extra energy to the diet of the cow. Both are dry products which will lend themselves for blending with other feed ingredients. Also both

contain a relatively high proportion of saturated fatty acids which helps reduce the likelihood of them altering the rumen fermentation.

How much extra fat can be fed?

The typical diet contains about 3 to 4 percent fat. This level can be increased to 7 to 8 percent of the total ration dry matter without any problem. At higher levels (up to 10-12 percent) some reduction in dry matter intake may occur with individual cows. Feeding the amounts of products listed in Table 2 will constitute a level of 7-8 percent in the diet.

When fat is added to the ration should other adjustments in the ration be made?

Yes. First make sure the ration contains adequate amounts of fiber to stimulate good rumen action. Increase the calcium level of the ration up to 1 percent because some calcium may be lost in the feces as soaps. Lastly, be sure to include a good source of protein that is of low rumen degradability. It should make up about 1 percent of the total ration dry matter. This is important because the fat replaces cereal grains resulting in a loss of energy to the rumen microorganism and less microbial protein will be available to the cow.

What are the potential benefits?

An increase in milk yield of 5 to 8 percent is generally observed. The higher the milk yield, the greater will be the response. Fat tests should be maintained or possibly increased if they were depressed because of high grain feeding. Lastly, it is likely that the good cows will be in better condition to conceive when bred at 75 to 90 days post calving.

Table 1. Week After Calving to Reach Maximum Yield and Maximum Dry Matter Intake and Energy Balance[1]. (Adapted from Proc. Distillers' Conf., p. 23, 1982).

Production Level	Max. Milk Yield (wk)	Max. Milk Yield (lb/day)	Max. Dry Matter Intake[1] (wk)	Max. Dry Matter Intake[1] (lb/day)	Energy balance[2] (wk)
High	7	110.2	14	54.4	21
Medium	8	72.4	13	42.8	13
Low	6	60.7	13	40.3	10

[1] Corrected to 1450 pound cow.

[2] Week when energy intake equalled energy requirement.

Table 2. Fat Sources for Lactating Cows.

Source	Percent fat	Recommended amounts to be fed
Oil Seeds		
Whole cottonseed	23	5 to 7 pounds/cow/day
Whole soybeans	19	4 to 5 pounds/cow/day
Whole sunflower seeds	30-40	3 to 4 pounds/cow/day
Fat Supplements		
Tallow	99	1 pound/cow/day
Hydrolyzed animal-vegatable blend	99	1 to 1.5 pounds/cow/day
Calcium salts of fatty acids	85	1.25 pounds/cow/day
Prilled fat	99	1.00 pounds/cow/day

Added Fat for Dairy Calves

Edwin H. Jaster, Gene C. McCoy, Richard F. Randle, Rohan L. Fernando, and Mark G. Cameron

Calf hutches have been successfully used on many dairy farms to prevent respiratory disease and avoid problems with humidity and spread of pathogenic organisms. Dairy producers in areas with cold winters have expressed concern about growth and survival of young calves. High losses in calf hutches occur during cold stress. Newborn calves have small amounts of body fat plus a relatively high energy requirement in relation to body weight. Recent reports indicate high fat milk replacers are superior to low fat milk replacers for total weight gains and efficiency of feed conversion. The objective of this study was to evaluate the addition of fat to whole milk and milk replacer diets during the winter season for dairy calves. Female calves in this 4-week feeding study were from the University of Illinois dairy herd. The experiment was initiated on December 14, 1985, through May 5, 1986. After receiving colostrum from their dam for 1 day and placed in calf hutches, 40 calves were assigned randomly to one of four dietary treatments. Treatments were 1) whole milk, 2) whole milk plus .15 pounds fat per day, (4 ounces of Super Calf Kit, 60% fat, Merrick's Inc., Middleton, WI), 3) milk replacer, and 4) milk replacer plus .15 pounds fat per day. Whole milk and milk replacer were fed twice daily at a level of 9% of body weight. Treatments 1 and 3 were pooled (no added fat) and treatments 2 and 4 were pooled (added fat) for evaluation of treatment effects. Growth and performance characteristics of the calves were recorded at parturition and weeks 1 to 4 of age. Body weight gain from parturition (week 0) through weeks 1 to 4 appears in Figure 1. A significant increase in gain by four weeks was noted for the calves fed the added fat diet (9.9 pounds) compared to no added fat (6.4 pounds). Growth parameters (heart girth and body length) and visual fecal score (looseness) were not different. Benefits of fat addition to whole milk or milk replacer diets appeared as increased body weight gain during the calfs first month of life.

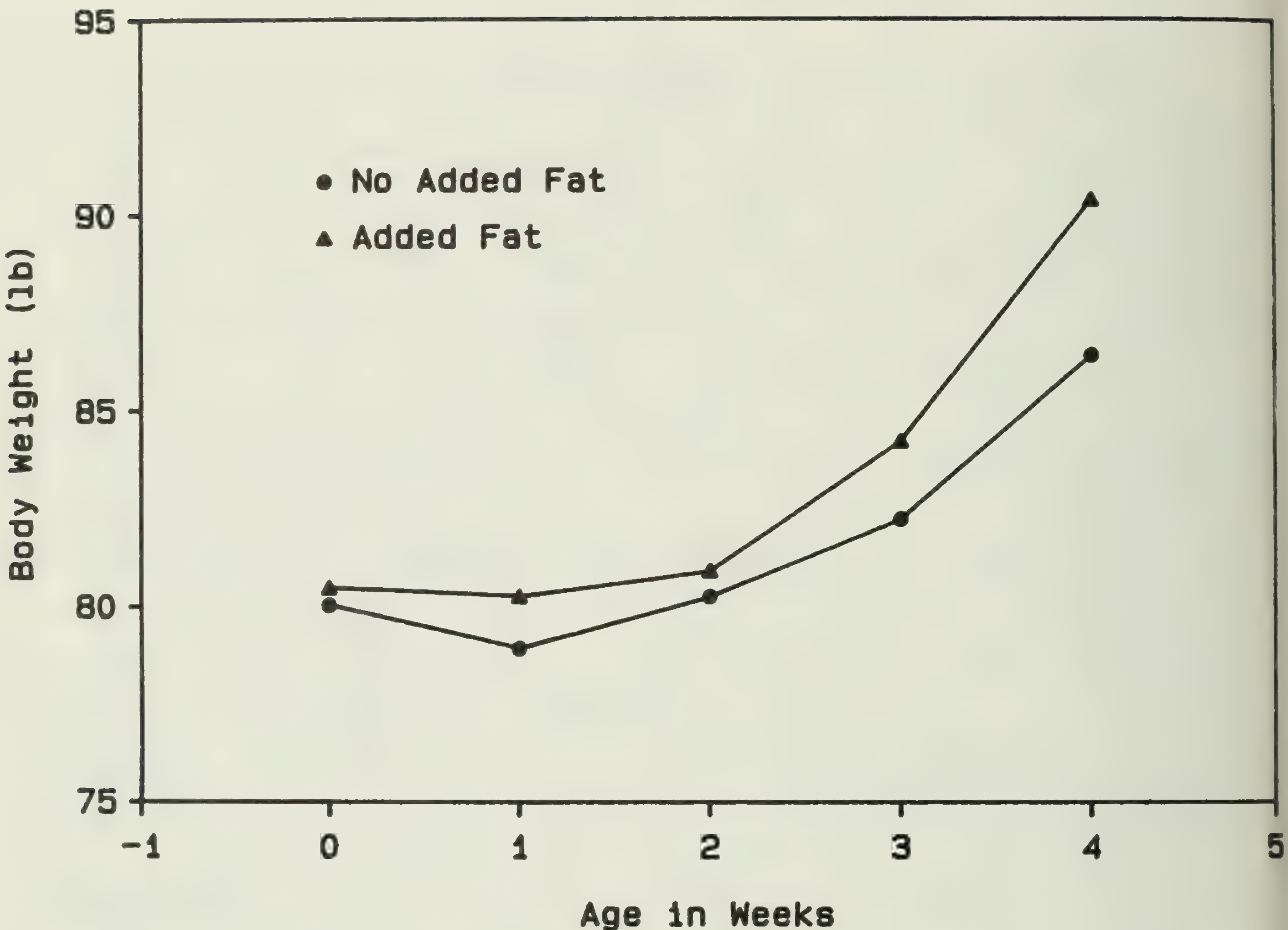


Figure 1. Weekly Body Weights of Calves on Whole Milk and Milk Replacer with Added Fat or No Added Fat

Evaluation of High-Oil Corn and Corn Silage Fed to Early-Lactation Dairy Cows

Edwin H. Jaster, David G. Atwell, and Gene C. McCoy

The typical dairy cow experiences a period of negative energy balance during the first 12 weeks of her lactation. Peak milk production (and therefore peak energy output) occurs between weeks 6 and 10 of lactation. However, maximum dry matter intake (DMI) (maximum energy input) occurs between weeks 14 and 16. Therefore, a period of negative energy balance evidenced by declining body weight occurs from weeks 1 through 12. The cow cannot meet the energy demands necessary for milk production and mobilizes body stores.

In order to maximize production and prevent ketosis, it becomes necessary to provide cows in early lactation with a diet high in energy density. Currently this need is accomplished by feeding diets with high levels of cereal grains. Several problems such as displaced abomasum, going off feed, rumen acidosis, and milk fat depression can occur with the feeding of high grain diets to dairy cattle.

Due to the higher energy density of lipids in comparison to carbohydrates, there has been interest by dairy producers and researchers in the feeding of oils to dairy cows. The underlying theory is to provide the cow with a diet which is high in energy density to meet the energy demands of peak milk production while still maintaining an adequate level of fiber in the diet to ensure proper rumen function and acceptable milk fat percentages. The objective of this study was to evaluate the feeding of kernoil corn (high oil corn) and kernoil corn silage (high oil corn silage) on feed intake, body weight change, milk yield, milk composition, and feed conversion to 4% fat corrected milk (FCM).

Forty multiparous Holstein cows were randomly assigned at parturition to one of four diets for the first twenty weeks of lactation. During the first three weeks of lactation all cows were fed a diet comprised of 25 percent high-oil concentrate, 25 percent regular concentrate, 25 percent high-oil corn silage and 25 percent regular corn silage on a dry matter basis (DMB). In addition, during the first and second week, cows received 10 pounds per day and 5 pounds per day, respectively, of long stemmed alfalfa-grass hay. This allowed for rumen adjustment from the dry period diets to the high energy and low fiber diets of early lactation. In the third week the long stem hay was removed from the diet and all animals were on a concentrate and corn silage diet. Beginning at week four and

---
[1] Kernoil, Pfister Hybrid Corn Company, El Paso, IL.

continuing through week 20, all cows were assigned to one of the experimental diets. Composition of diets were 1) regular corn (50 percent) and corn silage (50 percent), 2) regular corn (50 percent) and kernoil corn silage (50 percent), 3) kernoil corn (50 percent) and regular corn silage (50 percent), and 4) kernoil corn (50 percent) and kernoil corn silage (50 percent) expressed on a dry matter basis.

The chemical makeup of the diets are given in Table 1. Kernoil corn had 2.5 percentage units more crude protein than regular corn. Similarly, kernoil had 3.95 percentage units more oil (ether extract) than regular corn. Kernoil corn silage crude protein content was similar to regular corn silage, while oil content was greater (1.50 percentage units higher). An attempt was made to meet National Research Council dairy cow nutrition requirements by providing a total mixed ration containing 15 percent crude protein. Soybean meal, dicalcium phosphate, limestone, salt and vitamins A and D were added to both concentrate mixtures.

Dry matter intake (DMI) of cows during the experiment are given in Table 2. Highly significant increases in DMI occured when cows consumed high oil corn-corn silage mixtures. Body weight change (week 4 minus 20) followed similar trends as DMI, with kernoil corn-corn silage fed cows gaining significantly more body weight than other diets (Table 2). The addition of kernoil corn or kernoil corn silage to dairy cow rations prevented body weight loss in early lactation. There are benefits to preventing of rapid body weight loss in dairy cows during early lactation. Rapid body weight loss is associated with reduced DMI and the potential risk for metabolic disorders such as ketosis.

Mean daily milk production and milk composition are given in Table 2. Analysis of weekly milk production revealed no differences in production between diets. Similar trends were noted for milk fat and milk protein. Milk fat percentage was depressed in all diets. The low milk fat test results from the lack of fiber in the total diet. Acid detergent fiber level for the diets averaged approximately 15 percent ADF (calculated). Supplementing the diets with additional fiber could raise milk fat test.

The effect of Kernoil corn and corn silage on lactation efficiency are given in Table 2. The regular corn-corn silage had slight increase in efficiency of production (lb FCM/lb DMI) compared

to other diets. However, the gain in body weight by Kernoil fed cows partially explains the reduction in feed efficiency (Table 2). The apparent greater efficiency in production on regular corn and corn silage can be accounted for energetically by losses in body weight.

Conclusions are listed below.

1) Kernoil corn and corn silage resulted in higher DM intake than regular corn-corn silage.

2) Dairy cows consuming Kernoil diets were in positive energy balance throughout early lactation.

3) Additional fiber to all rations may benefit milk fat levels.

4) Reproductive performance was similar for all diets.

Table 1. Dry Matter, Crude Protein and Ether Extract Content of Feeds.

Item	Dry matter	Crude Protein[1]	Ether Extract[1]
	(%)	(%)	(%)
Corn	89.6	8.6	5.12
Kernoil corn	91.1	11.1	9.07
Corn silage	37.8	9.0	3.52
Kernoil corn silage	35.8	9.2	5.02

[1] Expressed as percent of dry matter.

Table 2. Dry Matter Consumption, Body Weight Changes and Milk Production Comparisons.

Item	Diets[1]			
	R	HOC	HOCS	HO
Dry matter intake (lb)	43.1	46.2	44.6	49.2
Dry matter intake (%B.W.)	3.45	3.40	3.56	3.73
Ave. daily change in body weight (lb/day)	-.26	+.16	+.12	+.37
Milk (lb/day)	85.2	86.0	89.5	90.3
4% Fat corrected (lb/day)	63.3	63.7	68.7	69.4
Milk fat (%)	2.37	2.27	2.45	2.46
Milk Protein (%)	2.83	2.82	2.89	2.84
Efficiency (lb FCM/lb DMI)	1.47	1.38	1.54	1.41

[1]
R = Regular corn and corn silage
HOCS = Regular corn and kernoil corn silage
HOC = Kernoil corn and regular corn silage
HO = Kernoil corn and kernoil corn silage

Brown Midrib Sorghum for Dairy Heifers

Edwin H. Jaster, Kenneth J. Moore, and Cindy L. Wedig

Lignin is an integral component of all plants. It serves a structural role to add rigidity to cell walls. Lignin is of interest to ruminant nutritionists because it is essentially indigestible, and interferes with digestion of plant cell wall carbohydrates. Poorly digested forages are associated with a high lignin content. Brown midrib mutants of sorghum have been developed which are lower in lignin content and have higher digestibilities than normal sorghum varieties (Lusk et al., J. Dairy Sci. 67:1739).

Brown midrib mutants contain an unpolymerized lignin monomer, characteristic of immature plant cell walls which decreases as lignin polymers form. They tend to have concentrations of ferulic acid similar to normal plant lignins, but less para-coumaric acid, para-hydroxybenzaldehyde, and syringealdehyde. Brown midrib mutants also tend to have much larger proportion of aldehyde groups than do their normal counterparts. Our objectives were to compare two Brown midrib sorghum-sudangrass hybrids and their normal corresponding genotypes when fed to dairy heifers.

Eight yearling Holstein-heifers, initially weighing 725 pounds, were assigned to four groups. Animals in each group were fed individually a sequence of four diets for four successive 21 day periods replicated in a Latin square design. The four dietary sorghum-sudangrass hybrid treatments were 1) Normal, Redlan x Piper 2) Brown midrib, Redlan x Piper 3) Normal, Redlan x Greenleaf and 4) Brown Midrib, Redlan x Greenleaf. Diets were offered ad libitum (10% refusal) and fed twice daily in equal portions.

Chemical analyses of each sorghum x sudangrass hybrid are shown in Table 1. Cell wall fiber (NDF), acid detergent fiber, and acid detergent lignin were lowest for the Redlan x Greenleaf brown midrib hybrid. Crude protein content of sorghum x sudangrass hybrids ranged from 8.7 to 10.3 percent. Recommended crude protein content of growing heifer rations is 12 percent. The sorghum-sudangrass varieties in this experiment were harvested more mature than recommended to accentuate cell wall differences. The sorghum-sudangrass quality would be improved by harvesting earlier. Nutrient intake and apparent digestibility of sorghum-sudangrass hybrids by dairy heifers appear in Table 2. Dry matter intakes for all diets averaged approximately 2 percent of body weight. However, heifers on brown midrib sorghum diets consumed less acid detergent lignin. Apparent organic matter, NDF, ADF, hemicellulose, cellulose and crude protein digestibility were greater for Redlan x Greenleaf brown midrib sorghum than the normal variety. Redlan x Piper normal and brown midrib sorghum had similar apparent digestion of fiber and protein by heifers. The development of brown midrib sorghums appear to offer dairy producers a relatively low lignin forage for dairy cattle feeding.

Table 1. Chemical Composition of Sorghum-Sudangrass Hybrids and Their Corresponding Brown Midrib Mutants.

	Redlan x Greenleaf normal	Redlan x Greenleaf brown midrib	Redlan x Piper normal	Redlan x Piper brown midrib
	-----------	----------- %	-----------	-----------
Dry matter	26.4	22.9	28.6	23.8
	------	(% dry matter basis)	------	------
Neutral detergent fiber (NDF)	67.3	65.2	67.2	65.2
Acid detergent fiber (ADF)	40.4	37.1	40.7	38.8
Acid detergent lignin (ADL)	4.8	3.2	4.7	3.7
Hemicellulose	26.9	28.2	26.6	26.4
Cellulose	35.0	33.1	35.4	34.3
Crude protein	10.3	10.9	8.7	9.5
Ash	9.5	10.3	9.6	11.1

Table 2. Nutrient Intake and Apparent Digestibility of Experimental Diets Fed to Dairy Heifers.

	Redlan x Greenleaf normal	Redlan x Greenleaf brown midrib	Redlan x Piper normal	Redlan x Piper brown midrib
Intake, lb/day				
Dry matter	13.2	14.3	13.4	13.2
Neutral detergent fiber (NDF)	8.8	9.2	9.0	8.6
Acid detergent fiber (ADF)	5.3	5.3	5.3	5.1
Acid detergent lignin (ADL)	.63	.46	.61	.46
Hemicellulose	3.5	3.9	3.5	3.5
Cellulose	4.6	5.3	4.8	4.4
Apparent Digestion, %				
Organic matter	54.6	64.2	56.3	54.8
	-------	Organic matter basis, %	-------	-------
Neutral detergent fiber	55.7	65.6	58.1	56.6
Acid detergent fiber	54.1	62.3	57.2	55.1
Hemicellulose	55.5	68.1	58.1	56.8
Cellulose	63.4	71.1	66.2	65.7
Crude Protein	46.0	54.6	39.4	45.8

Response to Level of Dry Matter Intake and Postruminal Casein Infusion on Milk Production and Plasma Hormone Concentrations in Dairy Cows

Wendie S. Cohick, John L. Vicini, Charles R. Staples, Jimmy H. Clark, Stuart N. McCutcheon, and Dale E. Bauman

Postruminal infusion of casein (milk protein) increases production of milk and milk protein by dairy cows. The mechanism by which casein or bypass protein elicits the improved performance has not been identified, but a change in plasma hormone concentrations has been suggested as one possible mode of action. However, little is known about the effects of postruminal infusion of protein on plasma concentrations of hormones in lactating dairy cows. Administration of bovine growth hormone to dairy cows has increased milk production. In some trials, hormone concentrations in plasma of ruminant animals have been altered by postruminal supplementation of protein or amino acids, but in other trials plasma hormone concentrations were not changed by providing protein or amino acids postruminally. Most of the data in the literature does not include the energy or protein status of the animals when hormone concentrations in plasma were measured.

In this trial, Holstein cows were used in a 4 x 4 Latin Square design to examine the interaction between effects of level of dry matter intake and postruminal infusions of water or 395 g per cow per day of casein on lactational performance, utilization of nitrogen and energy, and plasma concentrations of hormones. Cows were fed a complete mixed diet containing 15 percent crude protein and consisting of 50 percent concentrate, 25 percent corn silage, and 25 percent alfalfa haylage on a dry matter basis. The concentrate mixture consisted of ground shelled corn, 74 percent; soybean meal, 21 percent; dicalcium phosphate, 1.5 percent; limestone, .94 percent; sodium sulfate, .51 percent; trace mineral salt, 2.00 percent; and vitamin A and D supplement, .05 percent. Diets were offered in ad libitum or restricted (to provide 80 percent of nutrient requirements) amounts at 0700 and 1700 h each day. Cows were milked at 0500 and 1600 h.

Periods in the Latin Square were 10 days with the last seven days being used for collection of animal performance data. Nitrogen balance and apparent digestibility of diets were determined by total collection of feces and urine on days 4 through 8 of each period. Blood samples were obtained via indwelling jugular cannulae at hourly intervals during the last 24 hours of each period. Plasma samples obtained at hourly intervals were assayed for concentrations of growth hormone,

insulin, and glucagon. Plasma samples were assayed for glucose and nonesterified fatty acids at two hour intervals and for prolactin, thyroxine, and tri-iodothyronine at four hour intervals. Comparisons were made to statistically evaluate the effects of casein infusion, level of feed intake, and interaction of casein infusion and dry matter intake.

Yields of milk, milk protein, milk fat, and milk solids-not-fat were decreased by restricting feed intake. Milk and milk protein yields were increased by casein infusion, with no treatment interactions (Table 1). Restricting feed intake decreased total nitrogen intake by 143 g per day and resulted in smaller amounts of fecal, absorbed, urinary, milk, and retained nitrogen compared to cows fed ad libitum. Casein infusion increased total nitrogen intake (55 g per day), absorbed nitrogen (54 g per day), urinary nitrogen excretion (28 g per day), and milk nitrogen (13 g per day). Restricting feed intake increased plasma growth hormone and nonesterified fatty acids and decreased concentrations of insulin and tri-iodothyronine. Glucagon, prolactin, thyroxine, and glucose were not affected by level of dry matter intake. Casein infusion did not affect growth hormone, insulin, prolactin, tri-iodothyronine, thyroxine, glucose, or nonesterified fatty acids. Increases in milk and milk protein yields obtained with casein infusion were apparently not mediated through changes in circulating concentrations of these hormones. However, plasma glucagon was increased by casein infusions. Therefore, it is possible that gluconeogenic amino acids supplied during casein infusion increased rates of gluconeogenesis, thereby increasing glucose availability for milk synthesis. Additional studies are needed before it can be concluded that the increased milk production is due to additional gluconeogenic precursors supplied by casein and increased plasma concentrations of glucagon.

Table 1. *Least Squares Means for Dry Matter Intake, Milk Production, Composition of Milk, Nitrogen Intake and Utilization, and Concentrations of Metabolites and Hormones in Plasma of Cows Fed Two Amounts of Dry Matter and Infused Postruminally with Sodium Caseinate or Water.*

	Treatments			
	Ad libitum[1]		Restricted[1]	
Variable	Water[2]	Casein[2]	Water[2]	Casein[2]
Dry matter intake, lb/day	41.1	41.8	27.1	28.0
Dry matter digestibility, %	63.4	65.5	65.1	68.5
Digestible energy intake, Mcal/day	53.3	56.0	34.8	39.7
Digestible energy requirement, Mcal/day	50.6	51.5	46.3	48.7
Milk, lb/day	55.9	59.9	47.4	52.9
Milk protein, %	3.03	3.18	2.92	3.07
Milk fat, %	3.26	2.93	3.38	3.25
Milk solids-not-fat, %	8.43	8.35	8.14	8.31
Milk energy, Mcal/day	16.62	16.92	14.10	15.60
Nitrogen intake, g/day	420	474	276	332
Fecal nitrogen, g/day	179	178	113	106
Absorbed nitrogen, g/day	249	296	164	226
Urinary nitrogen, g/day	136	161	110	140
Milk nitrogen, g/day	124	134	102	118
Retained nitrogen, g/day	-11	1	-48	-31
Productive nitrogen, g/day	113	135	53	86
Nonesterified fatty acids, uEq/liter	237	241	284	290
Glucose, mg/100 ml	60.0	61.5	59.6	61.6
Prolactin, ng/100 ml	12.8	15.0	8.9	13.0
Tri-iodothyronine, ng/ml	.86	1.02	.75	.73
Thyroxine, ng/ml	42.1	48.6	42.6	42.6
Growth hormone, ng/ml	3.9	3.5	5.2	4.6
Insulin, ng/ml	2.5	2.6	1.9	2.3
Glucagon, pg/ml	244	279	241	269

[1] Refers to the quantity of dry matter offered to the cows.

[2] Refers to casein or water that was infused postruminally.

Effect of Immunization Against Somatostatin on Concentrations of Growth Hormone in Plasma and Growth of Holstein Calves

John L. Vicini, Jimmy H. Clark, Walter L. Hurley, and Janice M. Bahr

Administration of growth hormone (somatotropin) to ruminants increases milk production of lactating cows and growth of young animals. Secretion of growth hormone appears to be regulated by two peptides, growth hormone releasing factor and somatostatin. Growth hormone releasing factor is a 29, 40, or 44 amino acid peptide that stimulates secretion of growth hormone. Somatostatin is a 14 or 28 amino acid peptide that is secreted by the hypothalamus, pancreas, and intestinal tract. Somatostatin appears to alter the secretion of several of the major hormones, including growth hormone and glucagon, that are involved in metabolism and partitioning of nutrients to various tissues. Infusion of somatostatin has decreased body weight gains in rats and growth hormone concentrations in plasma of rats and sheep. Therefore, if the inhibitory influence of somatostatin could be removed by immunization of cattle, concentrations of metabolic hormones in plasma may be increased resulting in improved growth of young animals and milk production of lactating cows. Two trials were conducted to determine the effect of immunization against somatostatin on growth of Holstein calves and concentrations of growth hormone in plasma.

EXPERIMENTAL PROCEDURES

Trial 1. Five Holstein calves were immunized against somatostatin and compared to six control Holstein calves. At six weeks of age, calves were fed a pelleted diet ad libitum and 1 pound of alfalfa hay. Body weights were determined weekly and body measurements at two week intervals. Feeds and refusals were weighed daily to determine dry matter intake. Antigen injected was cylic somatostatin conjugated via carbodiimide to keyhole limpet hemocyanin. Primary immunization was at 7 weeks of age and consisted of subcutaneous injection of 14.8 mg of antigen (2.8 mg somatostatin) emulsified in saline and complete Freund's adjuvant. Booster injections consisted of 9.4 mg of antigen (1.4 mg somatostatin) in saline and incomplete Freund's adjuvant at 13 and 19 weeks of age. Control calves received similar injections with keyhole limpet hemocyanin but without somatostatin. Serum was obtained from calves by puncture of the jugular vein 7 days after each booster injection for determination of 125I-somatostatin binding. A teflon catheter was inserted into a jugular vein of each calf nine days after the last booster injection. The following day, blood samples were taken from 0700 to 1500 hour at 15 minute intervals. Growth hormone in plasma was determined by radioimmunoassay.

Trial 2. Five Holstein heifers were immunized against somatostatin and compared to five control heifers. Heifers were fed ad libitum a diet consisting of 41.7 percent concentrate, 38.9 percent corn silage, and 19.4 percent alfalfa hay. Feed intake was recorded daily and body weights were measured weekly. Body measurements were determined at two week intervals. Antigen injected was human alpha-globulin (control) or cyclic somatostatin conjugated via glutaraldehyde to human alpha-globulin. Prior to immunization, all heifers were preimmunized against the human alpha-globulin. The preimmunization injection consisted of 15 mg of human alpha-globulin in 2 ml of phosphate buffered saline, 1 ml of Bordetella pertussis vaccine, and 3 ml of incomplete Freund's adjuvant. Primary immunization was at 37 weeks of age and booster injections were given at 39 and 41 weeks of age. Primary and booster injections consisted of 17.9 mg of antigen (3.4 mg somatostatin) emulsified in saline and Freund's incomplete adjuvant in a total volume of 10 ml. Control heifers received similar injections with human alpha-globulin but without somatostatin. Serum samples were taken to determine 125I-somatostatin binding as described in trial 1. Twenty-three days after the last booster injection, polyvinyl catheters were inserted into a jugular vein of all heifers. Heparinized blood samples were taken every 20 minutes the following day from 1200 to 1800 hours and assayed for growth hormone by radioimmunoassay. Apparent nutrient digestibilities were determined on days 13 to 22 after the last booster injection using chromic oxide as an external digesta marker.

RESULTS

Antibody against somatostatin was present in all heifers immunized against somatostatin in both trial 1 and 2, but could not be detected in control heifers. When adjusted for birth weight and weight at time of immunization, final weights at 22 weeks of age were 408 and 446 pounds for control and immunized calves in trial 1 (Table 1). Average daily gains of immunized calves were increased ($P < .06$) compared to control calves. Height at withers, depth of chest, body length, heart girth, efficiency of feed utilization, and plasma growth hormone concentrations were not different between treated and control calves.

In trial 2, body weight gain, height at withers, depth of chest, body length, heart girth, dry matter intake, and efficiency of feed utilization were not different between treated and control heifers (Table 1). Somatostatin has been shown to affect motility of the intestinal tract which could affect apparent nutrient digestibilities. However, apparent total tract digestibility of dry matter, crude protein, and acid detergent fiber did not differ between immunized and control heifers. Growth hormone concentrations were two-fold greater in the plasma of somatostatin immunized heifers compared to control heifers, but means were not significantly different because of the large variation among animals.

An increased growth of calves in trial 1 and a trend for increased concentrations of growth hormone in plasma in trial 2 was observed. Similar findings have been reported in other trials, but an increase in

concentration of growth hormone in plasma and an improvement in animal performance have not been observed in the same trial. The immunization techniques used in these trials produced antibody to somatostatin and the improved body weight gains observed in trial 1 suggest that this technique may result in improved growth. Trials need to be conducted with a larger number of animals in a longer trial to validate the improvement in animal performance when animals are immunized against somatostatin.

Table 1. Effect of Immunization Against Somatostatin on Growth Parameters, Feed Intake, and Plasma Growth Hormone.

Parameter	Treatment	
	Control	Immunized
Trial 1		
Final weight, lb	408	446
Average daily gain, lb/day	2.6	2.9*
Height at withers, in.	40.0	41.1
Depth of chest, in.	18.8	19.8
Girth, in.	50.8	52.0
Body length, in.	41.6	42.8
Dry matter intake, lb/day	8.36	9.46
Weight gain (lb)/dry matter (lb) intake	.26	.26
Plasma growth hormone, ng/ml	6.96	7.44
Trial 2		
Final weight, lb	797	813
Average daily gain, lb/day	2.33	2.49
Height at withers, in.	48.1	48.6
Depth of chest, in.	24.5	24.7
Girth, in.	66.2	67.2
Body length, in.	50.8	50.9
Dry matter intake, lb/day	16.7	16.7
Weight gain (lb)/dry matter (lb) intake	.14	.14
Apparent digestibility, %		
Dry matter	64.3	68.0
Crude protein	52.1	55.0
Acid detergent fiber	51.8	53.1
Plasma growth hormone, ng/ml	3.35	7.86
Plasma urea-nitrogen, mg/dl	8.84	8.02

*Significant difference ($P < .06$).

The Effect of Gonadotrophin Releasing Hormone on Dairy Cattle Fertility

J. Robert Lodge

One of the major concerns of dairy farmers is getting animals pregnant. Although missing heats is a major problem, conception of animals bred is a common complaint. There are many causes for lack of conception, one of which is improper timing of insemination. Gonadotrophin releasing hormone (GnRH) is a hormone from the hypothalamus which acts on the anterior pituitary to cause the release of leuteinizing hormone which causes the mature follicle to ovulate releasing the oocyte (egg) for fertilization. GnRH has been used in several situations to induce ovulation. Several studies have been conducted to study the effect of GnRH at varying times in association with insemination. The only clear result emerging from these studies is that using GnRH on repeat breeder cows improves fertility. A study was designed to examine the influence of GnRH injected at the time of insemination on fertility.

Animals in the University of Illinois dairy herd were used from the end of January to early in May, 1986. The study was designed so that every other animal presented for insemination would receive an intramuscular injection of 100 micrograms GnRH. Those not injected would serve as controls. An animal receiving GnRH was to receive injections at any subsequent inseminations.

When the study was completed in early May, 178 animals had been included. Thirty-two animals had inadvertantly been switched from controls to GnRH or vice versa during the course of the study. Seventeen animals left the herd with their reproductive status unknown at the time of culling. Forty-two heifers were included in the study with four being switched and two left the herd. After removing those animals which left the herd or were switched during the study, the results showed 70 controls with 45.7 percent pregnant and 66 GnRH treatment animals 47.0 percent pregnant; very little difference between the control and treated animals. On the other hand, if all animals were included except those leaving the herd, 97 control animals showed 51.5 percent pregnant with 2.2 services per conception and 96 GnRH treated animals showed 61.4 percent pregnant with 1.7 services per conception. This shows about a 10 percent advantage for GnRH treated animals. Most of this difference occurs because of 20 animals which originally were controls and later received GnRH. Fifteen became pregnant following the GnRH treatment. Ten of these pregnancies resulted from the first insemination, four from the second, and one from the third insemination with GnRH. The pregnancy rate for these animals was 75 percent. Of the five animals switched from GnRH to controls, two became pregnant (one with one and one with two inseminations) for 40

percent pregnancy rate. If three heifers are removed from the control to GnRH group, 17 cows had a 82.4 percent pregnancy rate.

Forty-two heifers were included in the study with four being switched (all from control to GnRH). Thus, there were 19 heifers for each group, the control and the GnRH treated. The pregnancy rate for the controls was 68.4 percent and for the GnRH treated was 78.9 percent. Of the 15 pregnancies following GnRH treatment, nine had been inseminated one or more times prior to the treatment. Of these nine, seven became pregnant after the initial insemination with GnRH treatment.

These results suggest that it would not be adviseable or economically feasible to inject all animals with GnRH at the time of insemination. However, fertility appears to be increased when GnRH is used on repeat breeder animals. This latter increase has also been reported by others. The author is not aware of previous studies with heifers and, even though the numbers in this study are small, the results strongly suggest a definite advantage for using GnRH on repeat breeder heifers as well as cows.

1988 Illinois Dairy Report

Department of Animal Sciences
Cooperative Extension Service
Agricultural Experiment Station
College of Agriculture
University of Illinois at Urbana-Champaign

Focus on the Future

1988 Illinois Dairy Days

January	11	Kankakee, Redwood Inn
	12	Marengo, Cloven Hoof Restaurant
	13	Freeport, Masonic Temple
	13	Elizabeth, Community Bldg
	14	Sterling, Emerald Hill Country Club
January	15	Pekin, Agricultural Center
	19	Quincy, Farm Bureau Building
	20	St. Libory, American Legion Hall
	21	Breese, American Legion Hall
	22	Teutopolis, Knights of Columbus Hall

Authors

Department of Animal Sciences, University of Illinois at Urbana-Champaign, except as noted:

MARK G. CAMERON, research assistant, management
JIMMY H. CLARK, professor, nutrition
CARL L. DAVIS, professor emeritus, nutrition
BRADLEY A. DIDION, research assistant, physiology
TED L. FUNK, area agricultural engineer, Effingham
W. R. (REG) GOMES, professor and head, physiology
CHARLES N. GRAVES, associate professor, physiology
MICHAEL F. HUTJENS, professor, extension
EDWIN H. JASTER, associate professor, management
JOANNE SICILIANO-JONES, research assistant, nutrition
TIM H. KLUSMEYER, research assistant, nutrition
ROBERT D. McCARTHY, Jr., research assistant, nutrition
R. DAVID McQUEEN, professor, College of Veterinary Medicine, extension
MICHAEL R. MURPHY, associate professor, nutrition
DALE R. NELSON, professor, College of Veterinary Medicine, clinical medicine
JAMES L. ROBINSON, professor, biochemistry
ROGER D. SHANKS, associate professor, genetics
SIDNEY L. SPAHR, professor, management
COLLEEN M. WAGNER, research assistant, physiology

Contents

1988 Theme: Focus on the Future

University of Illinois Research Reports

The Department of Animal Sciences

W. R. (Reg) Gomes

It is a pleasure for me to introduce the Illinois Dairy Report and to welcome you to our 1988 Dairy Days Program. Both the Report and the series of meetings around the state help us to keep the latest information on dairy research available to you. In addition to these methods, we continue to produce the Illinois-Iowa Dairy Handbook, the Illini Dairy Guide, and other programs or publications as necessary. In 1987 we joined our extension colleagues from Iowa, Minnesota, and Wisconsin in presenting a 4-state dairy days; the program was so successful that we plan another for 1988.

Our undergraduate programs, including our judging team, the Milk-a-Cow Book at the State Fair, and too many activities of the Illini Dairy Club to list here, continue to keep our students active and involved. With the formation of the Department of Animal Sciences, our courses have been renumbered and our curricula revised, but opportunities for dairy courses and a dairy option remain.

Our research faculty are involved in studies that will influence dairying in and beyond Illinois next year and into the distant future. We invite your questions, suggestions, and comments on all of our programs. We appreciate your support and invite you to visit us whenever you are in Urbana.

Dairy Faculty in the Department of Animal Sciences

Faculty	Specialization
Marvin P. Bryant, professor	Ruminant microbiology
Jimmy H. Clark, professor	Dairy cattle nutrition
Charles N. Graves, associate professor	Reproductive physiology
W. R. (Reg) Gomes, professor	Reproductive physiology
Michael Grossman, professor	Dairy breeding & genetics
Walter L. Hurley, assistant professor	Lactation endocrinology
Michael F. Hutjens, professor	Extension dairyman
Edwin H. Jaster, associate professor	Dairy cattle management
Bruce L. Larson, professor	Biochemistry & lactation
J. Robert Lodge, professor	Reproductive physiology
Gene C. McCoy, farm manager	Dairy cattle management
Michael R. Murphy, associate professor	Dairy cattle nutrition
James L. Robinson, professor	Biochemistry
Roger D. Shanks, associate professor	Dairy breeding & genetics
Sidney L. Spahr, professor	Dairy cattle management
Bryan A. White, assistant professor	Ruminant microbiology

Building and Delivering Grain Mixtures

Michael F. Hutjens

Even though forage is the foundation of dairy rations, grain mixtures provide extra energy, protein, minerals, vitamins, and additives. Grain mixtures have high energy values per unit of dry matter, can be consumed in large amounts because they contain less fiber, and can serve as a carrier of additional nutrients. Grain mixtures should have the following characteristics.

- Balance energy needs
- Provide protein complimenting forage levels
- Be palatable
- Contain high quality ingredients
- Deliver needed micronutrients
- Be least cost

The concentrate portion of the diet can represent 35 to 60 percent of the total feed cost. Wide price ranges occur due to additive, protein, and mineral-vitamin programs. Dairy managers must make several key decisions concerning the concentrate portion of the diet including ingredient selection, amount to feed to each cow, and the delivery system.

BUILDING THE GRAIN MIXTURE

Ingredient selection is the first decision on all dairy farms. Economics, home grown grains, storage facilities, feed sales personnel, and mechanization will influence choices. Each broad area will be briefly discussed. Table 1 summarizes feed values, economic factors, and suggested levels.

Energy is the primary reason grain is fed. Shelled or ear corn is the most common and economical source. High starch or soluble carbohydrate mixtures can cause acidosis and off-feed problems. Adding cob, hulls, or brans can improve digestibility and intake. Fermented and finely processed grains also produce more rumen acidic conditions. Adding a digestible fiber source (such as soyhulls, beet pulp, or corn bran can improve total performance. The level of bulk ingredient varies from 15 to 50 percent.

Protein level and degradability should complement the forage portion of the diet and balance the animal's needs. Soybean meal is the most economical source of protein in the midwest region. As milk yields increase (over 60 to 70 pounds of 4% FCM), proteins lower in rumen degradation should be selected. Rumen microbes can synthesize 3 to 4 pounds of microbial protein per day while typical ration ingredients will provide another 2 to 3 pounds of nondegraded protein. The amino acid profile of the nondegraded protein should also be balanced (corn gluten meal and corn distillers are low in lysine while soybean meal and animal-fish by-products have more desirable profiles).

Fiber has been mentioned earlier as an energy source. Ingredients high in NDF while lower in ADF would be beneficial for high producing cows (beet pulp and soyhulls are examples). However, for every one percent increase in crude fiber (listed on feed tags), a drop of one percentage point in TDN value occurs.

Fat should be added when cows are energy deficient and are consuming maximum dry matter and concentrate levels. Adding 1 to 1 1/2 pounds of fat (5 to 6 percent in the total ration, or 8 to 10 percent in the grain mixture) can improve milk yield, stabilize fat test, improve herd health, and increase reproductive efficiency. Oilseeds are usually the most economical source with cottonseed superior to soybeans. Inert fats (prilled and Megalac, a brand name) can be fed at higher levels with no negative rumen effects.

Minerals, vitamins, and additives guidelines are summarized in Table 2. Palatability can be a problem with high levels of micronutrients. Adding over 5 percent can reduce palatability when fed to finicky cows; levels over 10 percent can depress consumption. Feeding 15 to 20 percent mineral (usually salt in a grain mixture) can be used to control and limit free choice grain consumption.

A final "factor" is form. A coarse particle size is desirable (rolled, cracked, or crimped are examples). Finely processed particles are dusty, difficult to swallow, and slows the rate of rumen flow. Adding water, fat, or liquid molasses can minimize these problems. Pelleted grain mixtures will be consumed faster than meal forms (1 pound vs .4 to .7 pounds per minute) and flows freer in mechanical feeders. However, the grain mixture is ground finely prior to pelleting which can lead to lower rumen pH and milk fat test.

DELIVERING THE GRAIN MIXTURE

Allocation of feeds is one of the most important considerations in successfully feeding dairy cattle. The objectives of successful feeding systems are listed.

- Economically feed each cow to optimize income-over feed cost (IOFC)

- Maximize and monitor dry matter intake

- Minimize rumen fluctuations while maximizing microbial yield and end products

- Insure a steady flow of nutrients to the bloodstream for target tissue use

- Maximize feed digestibility and nutrient availability from feedstuffs

Electronic Computer-Controlled Feeders

Feeding concentrates to dairy cows to complement forages consumed has occurred as the cow is milked in conventional barns or milk parlors. With the trend to more milking parlors and higher concentrate needs, control of concentrate feeding is critical (Table 3).

Several earlier systems are being used by dairy producers. Ad libitum concentrate to cows in a separate group allows these cows extra time to consume concentrate. This practice requires extra labor and does not control intake to individual cows. Topdressing forage is another method to feed extra concentrate. Limitations to this approach include feed selectivity, boss cows control, and individual feeding does not occur. Magnet-activated feeders attempted to selectively feed only certain cows. While successful results have been reported, overconsumption of grain, boss cows, lack of concentrate control, lower fat test and off-feed problems, and negative economic responses have occurred. Electronically controlled feeding doors use the same principle and has similar limitations as the magnet feeder. However, any combination of forage and concentrate can be fed behind the doors in this system. Transponder-feeders regulate the total amount of concentrate to each cow in a 24 hour time period. The main problem was manual adjustment of the device which required catching the cow and extra labor. Manual and automatic concentrate drops in conventional barns allow multiple feedings of concentrate to individual cows.

Electronic computer-controlled feeders (ECCF) are improving yearly and include the best aspects of conventional systems.

- Multiple feedings of concentrate (maximum of five pounds per meal)

- Individual control of concentrates according to nutrient needs

- Record concentrate consumption patterns and refusals (evaluate health and estrus status)

- Ability to feed 1 to 3 different concentrate mixtures

- Automatically adjust concentrate intake based on a pre-determined equation or curve

- Ability to electronically identify the cow

Economics is a concern since installations cost from $8,000 to $20,000 per farm or $150 to $400 per cow. An Ohio field study reported a decrease in concentrate cost of 19 percent, an increase of 1.5 to 2.0 pounds of milk per cow per day, and a pay-back in less than two years after installation.

Dual feeder capacity permits varying amounts of two feeds. An energy and protein concentrate mixture are ideal. Including minerals and vitamins in both feeds allow flexibility. Feed additives can be included in the protein mixture, but palatability must be considered. Dealer support and installation are critical in selecting the brand. All units work if the dealer is skilled. Lease arrangements are also available. The unit can used to add body condition to dry cows, lead-feed close-up dry cows, and adjust first-calf heifers 2 to 3 weeks before calving. Allowing 2 to 3 days postpartum before gradually increasing concentrate at a rate of 1 to 1 1/2 pounds per day or following a predetermined equation or curve can stabilize the rumen environment. Each unit can dispense 500 pounds of concentrate a day with 20 to 30 cows per stall. Calibration and dispensing rate of each unit should be checked weekly and when a new concentrate mixture is used. Delivery rates of 1/2 pound (meal form) and 3/4 pound (pellet form) are typical. Feeder location should allow maximum cow use by avoiding high-traffic areas (holding areas or parlor exits), place feeders in series 10 to 12 feet apart, do not place units in freestalls opposite one another, and protect the cow with a partition (long enough to protect but not let timid cows hide, and wide enough not to appear as a chute). Feeding some concentrate with forage can improve forage intake with the ECCF topdressing cows producing above the nutrients provided by the bunk mixture. Concentrate intake should be adjusted daily for the initial three weeks postpartum, weekly from three weeks to 12 weeks (maximum dry matter intake), and monthly from 12 weeks to the end of the lactation. Each feeder and stall should be grounded to eliminate the possibility of electrical shock or stray voltage. A lighting arrestor must be installed.

Complete Rations

Complete ration (CR) concept is a system of weighing and blending all feedstuffs into a complete diet and offered free choice which supplies adequate nourishment to meet the needs of dairy cows. Advantages include no parlor concentrate feeding, more control over total feeding programs, less labor, and lower cost housing and feeding facilities. Disadvantages include the need for expensive specialized equipment, difficulty in feeding hay, and the need to group cows. Using a Cornell field study (80 cows producing 17000 pounds of milk) updated for 1985 production costs, CR returned an annual profit of $5155 over all costs. Every one pound increase in milk yield added $2640 income while a .1 percent increase in fat test added $2300 annually.

Three milk production and two dry cow groups are optimal. Groups of cows should be shifted monthly based on fat corrected milk yield, body condition, and age. A proposed Israeli study for shifting cows is based on dry matter intake (DMI), days in lactation, and milk yield potential (Figure 1) in the initital 45 days postpartum. Cows are challenged to estimate milk potential. Cows over 83.6 pounds of milk (38 kg) were maintained on the high diet until body condition dictated movement to the low diet in late lactation. Cows under 83.6 pounds of milk were moved to the low potential groups. Based on DMI, ration energy concentration, feed prices, and milk prices; the milk yield to shift cows could be altered. Differences in DMI (10 to 12 lb) and energy concentration (.75 vs .80 Mcal per pound of DM) are important. Cows should be transferred to their permanent group not later than the time of peak DMI. Refinement of this system includes evaluating the

the cow at peak milk (14 to 60 instead of 45 days). Maximum energy concentrations suggested by NRC-78 is .78 Mcal per pound of dry matter.

Virginia data revealed a 2.2 pound average decrease in production of nearly 6000 cows in seven herds within one day after shifting from a high to low group. Little change occurred in herds accustom to shifting while new CR herds were most adversely affected until the third shift. Cows spend less time eating, consume few meals, and do not lie down as much the day after shifting groups. Large herds form groups which do not change during lactation. A first lactation group can also increase milk yield in young cows.

Feeding frequency of CR should be evaluated based on DMI. Cows normally eat a large meal after each milking and each feeding. If high producing cows consume more dry matter by feeding 3 to 4 times a day, the practice should be continued. Fewer feedings are needed for low producing cows and during cold weather. Diets over 50 percent moisture can reduce total dry matter intake. Israeli researchers reported 6 to 9 percent high intake with drier rations. Moisture content is not the main effect on DMI, but is related to fermentation products produced during ensiling, intracellular vs extracellular water, and feed pH on rumen microbes and environments. Optimum ration dry matter appears to be 55 to 75 percent with a maximum intake of 100 to 110 pounds of wet fermented feed per day.

Forage testing is critical and should include dry matter, total protein, ADF-nitrogen (heat damage), ADF, NDF, and macro and micro minerals. A quality control check is having the bunk mix analyzed (take 6 to 10 grab samples from the bunk, composite, and analyze). If the bunk mix analysis does not match, a mixing problem or feed quality change could have occurred.

Lead factors refer to the level of milk production to formulate above the current group milk yield average. Days in milk, lactation number, reproductive status, and body condition are considerations along with milk yield and fat test. One approach is to base lead factors on grouping schemes (Table 4).

Mixing wagon capacity will depend on herd size and feeding frequency. If future herd expansion is possible, the size should allow for growth. Barrel-type mixers are increasing in popularity since less wear occurs, power needs are reduced, and smaller batch sizes can be mixed. Overloading barrel mixers result in poor mixing.

DETERMINING CONCENTRATE INTAKE

Concentrate needs must be accurately determined irregardless of the method used. Factors that can influence the amount and composition of concentrates are listed.

- Milk yield and fat test

- Body weight (maintenance needs and intake potential)

- Forage intake and digestibility (nutrient sources)
- Body condition changes (increasing or decreasing)
- Age (growth factor)
- Days postpartum (lead factor for increasing milk yield)
- Days postpartum (reduce dry matter intake in early lactation, as high as 18 percent)

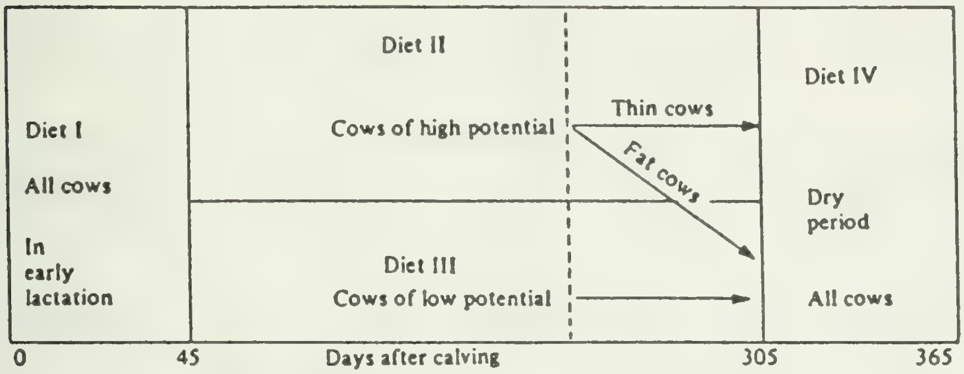


Fig. 1. Proposal for a feeding strategy in a large herd (Israeli data)

Table 1. Nutrient Content of Grains, Protein Supplements, and By-Product Feeds of Dairy Cattle (expressed on a 100% dry matter basis)

	Net energy (Mcal/lb)	ADF (%)	NDF (%)	Crude protein (%)	Nondegraded protein (% total)	Ether extract (%)	Calcium (%)	Phosphorus (%)	Upper limit (% conc mix)	Morrison Energy	Constant Protein
				Home-grown grains							
Barley	.88	7	19	13.5	30	2.1	0.05	0.38	80	0.908	0.093
Corn, shelled	.92	3	9	10.0	50	4.3	0.03	0.29	80	Base	Base
Corn, ear	.87	10	28	9.0	50	3.7	0.07	0.27	100	0.918	-0.018
Sorghum	.90	5	23	12.4	60	3.1	0.04	0.33	80	0.916	-0.056
Oats	.80	16	32	13.3	30	5.4	0.07	0.38	50	0.806	0.095
Wheat	.93	4	13	16.0	25	2.0	0.04	0.42	50	0.875	0.125
				Protein supplements							
Cottonseed meal	.79	19	26	45.6	40	1.3	0.21	1.16	40	0.128	0.773
Linseed meal	.81	19	25	38.3	40	1.5	0.43	0.89	40	0.201	0.699
Soybean meal (solvent)	.84	10	14	49.9	35	1.5	0.29	0.68	40	Base	Base
Soybean meal (mech)	.89	NA	NA	47.7	50	5.3	0.29	0.68	40	0.153	0.854
Soybean meal (dehulled)	.91	6	10	55.1	25	1.0	0.29	0.70	40	-0.116	1.123
Soybeans	.96	10	NA	42.8	25	18.8	0.28	0.66	20	0.352	0.746
				By-product feeds							
Beet pulp	.77	33	54	9.7	35	0.6	0.69	0.10	50	0.931	-0.051
Brewers' grain (dry)	.68	24	46	29.4	60	7.2	0.33	0.55	50	0.374	0.464
Corncobs	.50	35	89	3.2	50	0.7	0.12	0.04	25	NA	NA
Corn distillers' grain	.90	18	44	23.0	50	9.8	0.15	0.71	40	0.710	0.350
Corn gluten feed, dry	.87	16	38	25.6	35	2.4	0.36	0.82	50	0.456	0.434
Corn gluten meal	.94	5	14	67.2	65	2.4	0.08	0.54	40	-0.322	1.287
Cottonseed, whole	1.01	29	39	23.9	35	23.1	0.16	0.75	1[illegible]	0.656	0.303
Hominy feed	.91	13	55	11.5	NA	7.7	0.05	0.57	80	1.043	0.012
Malt sprouts	.74	18	47	28.1	55	1.4	0.23	0.75	20	0.908	0.093
Molasses, cane	.73	0	0	10.3	0	0.9	1.00	0.11	5	1.058	-0.169
Wheat bran	.73	15	51	17.1	NA	4.4	0.13	1.38	35	0.619	0.218
Wheat midds	.71	NA	37	18.4	50	4.9	0.13	0.99	25	0.743	0.222

Table 2. Micronutrients and additives that could be delivered by the grain mixture (high producing, early lactation cows)

Micronutrient	Amount (mg/day)	Level in total ration (ppm)
Cobalt	1.8	0.1
Copper	225	15[a]
Iodine	12	0.5
Iron	900	100[a]
Manganese	1125	50[a]
Selenium	6	.3
Zinc	1350	60[a]
	(IU/day)	
Vitamin A	100,000	100,000
Vitamin D	30,000	30,000
Vitamin E	400	400
	(g/day)	(%)
Niacin	6	NA
Bicarb/Sesquicarb	150	.75
Magnesium Oxide	45	.25
Isoacids	85	NA
Methionine/MHA	20-30	NA
Yeast	10	NA
Yeast culture	115	NA
Sodium bentonite	454	2.0

a. Includes feed and premix supplement sources

Table 3. Grain feeding methods in the Mid-States region (Keown, 1987)

Method	Percent	Milk Yield (lb)
Hand scoop	34	15672
Scoop shovel	6	15383
Mixer wagon (scales)	8	16286
Mixer wagon (no scales)	4	15286
Feed cart (scales)	1	16074
Computer controlled	11	15783
Hand lever (parlor)	30	15055
Free choice	7	15223

Table 4. Lead factors for total mixed ration formulation (Source: Virginia)

Percent of cows in each group			Lead factor for milk		
High	Medium	Low	High	Medium	Low
100	0	0	1.32	-	-
70	0	30	1.22	-	1.21
50	0	50	1.17	-	1.23
30	0	70	1.14	-	1.25
33	33	33	1.14	1.10	1.21
50	25	25	1.18	1.08	1.21

Forage Preservation and Utilization

Edwin H. Jaster

Maintaining a high quality forage during harvest and storage can increase both milk production and overall feed efficiency. Methods to reduce harvest and storage losses involve the conservation of forage. The manner in which forage is preserved greatly influences forage quality and animal production. Forages perform the following functions: 1) maintain rumen digestion and function, 2) promote rumen microbes that maintain milk production and fat tests, 3) foster rumination (cud-chewing) which buffers the rumen and maintains an optimal acid level (pH), 4) produce rumen acids (primarily acetic acid) for productive functions in the dairy cow, and 5) provide an economical source of nutrients.

Seasonal supply of nutrients from harvested forage makes conservation essential for year-round dairy production. The principles of hay-making and silage-making and appropriate management practices are important for production of high quality forage. Forage research and field observations indicate that a quality forage contains a high level of digestible energy and is consumed by dairy cattle in large amounts per unit of time. High quality forage should contain an abundance of minerals and vitamins, is leafy, has no mold or foreign material and is green in color. Table 1 summarizes the various nutritive components of forages and factors limiting animal utilization. Legumes (i.e., alfalfa) as a forage source for dairy cattle are generally more digestible than grasses, and contain less fiber and more digestible solubles. The lower cell wall content of legumes results in higher intake than grasses and less fiber to occupy space in rumen and limit intake. High levels of cell wall in forage reduce rates of digestion and passage which further limits intake.

PRODUCING QUALITY HAY

Forage quality is closely related to stage of maturity in the field. Dry matter yield increases while dry matter digestibility decreases with maturity (Figure 1). In general it is recommended to harvest alfalfa to maximize both yield and quality. Nutritive quality is reduced with physiological maturity. Allowing forages to mature results in reduced protein, digestibility, intake of forage, and milk production (Table 2). Increasing the proportion of concentrate in the ration can replace nutrients not present in poor quality

forage. This solution works in "average" producing herds. High producing cows (over 25,000 pounds of milk per cow per year) in early part of lactation cannot afford to be fed low quality forage and maintain maximum nutrient intake. Forage digestibility (TDN) drops about one-half percent each day cutting is delayed past early bloom. Also, the amount the cow eats drops during this period at more than one-half percent per day. The overall result is a 1 percent drop in feed value for each day cutting is delayed after early bloom.

Many forages are harvested after they have wilted and dried in the field. The objective of hay-making is to manage a rapid moisture loss after cutting so the forage can be removed from field with a minimum of losses from weathering and microbial degradation. The moisture content (MC) of an active growing forage plant is approximately 85-90 percent. Hay must be field cured down to 20 percent MC for safe storage of small bales and 18 percent MC for large hay packages. To produce 1 ton of hay at 20 percent MC requires the removal of approximately 7 tons of water from 8 tons of fresh forage. Hay drying can be described as a two phase process (fast and slow). The initial drying of forage is rapid with 75 percent of the water loss in the first 20 percent of the drying time. When forage is below 30 percent MC, drying becomes very difficult. Rate of drying is equal to the vapor pressure differences between ambient air, swath environment, and forage tissue characteristics. The drying power of atmosphere determines the ease of water release from plant.

After forage is cut, water leaves plant from pore openings in surface and cut ends. Leaf and stem pores close at approximately 60 percent MC and drying continues at a much slower rate from cut ends. Plant cells are alive until moisture content reaches approximately 40 percent and then cells begin to die. Hay drying involves relative humidity (RH) and water in plant. In the field little drying occurs when RH is above 60 percent. The National Weather Service has developed guidelines for forecasting curing times (Table 3). The shorter curing times are based on sunny conditions and the longer times are used to account for lighter winds and moist surfaces (dews, rain, and wet soils). This data can be used to approximate curing times during fairly uniform weather.

Field losses occur primarily from respiration, weather, and mechanical losses. When forages are cut, respiration continues until plant dries to 40 percent MC. Slow drying to 40 percent MC results in the loss in sugars, starches, and other readily available carbohydrates. The metabolic losses may vary between 2 to 16 percent of the dry matter. Total loss is influenced by ambient temperature and forage dry matter. Cutting hay in the evening will increase respiratory losses. Methods to speed up drying involve the use of crushing or crimping (conditioning) freshly cut forage. Conditioning forages breaks the waxy surface of stems and creates more cut ends allowing them to dry at a rate more equal to leaves. Other methods to increase drying rates utilize the addition of chemicals to the surface of plant at cutting causing the breakup of the waxy surface on stem. Generally, potassium carbonate and sodium carbonate plus other surface active agents are used to treat plants at cutting (Table 4). Chemical conditioners only work on legumes, not grasses. A dilute solution of chemicals are directed at stem from a push-bar ahead of cutter. Normally 8 to 10 pounds of active ingredient per ton of forage (30-40 gallons per acre) are applied to forage. Materials cost \$4 to \$10 per ton of hay.

Losses associated with hay making during good weather are generally less than 10 percent DM. However, rain causes the plant cells to continue respiration, a leaching of soluble nutrients from dried plant cells and indirectly considerable leaf loss. Poor drying weather causes an environment favorable for microorganisms that cause fermentative loss. Dry matter losses associated with good, moderate, and poor weather are generally 10, 20 or 30 percent, respectively. Unfavorable drying conditions with wetted hay may result in average DM loss to 40 percent.

Mechanical losses involve leaf shattering and leaves not picked up at baling. Dry matter losses (mainly leaves) increase with mowing and/or conditioning, tedding (turning), raking, and final baling and loading. Leaf loss with vigorous handling by raking are 5, 10, and 20 percent at moisture content of 50, 35, and 20 percent. Recent advances in mower-conditioners which cut hay with a sickle bar or disk mower and conditioner allow operator to form a wide windrow to speed up drying. A dense swath dries slow and air movement is limited. The swath may be spread with a tedder immediately after mowing over entire field surface. Radiation is absorbed by the wide uneven swath and improves drying rate. Tedding is fairly ineffective when hay is below 50 percent MC.

Hay losses during storage are primarily because of continued plant respiration, activity of microorganisms, and chemical oxidation. Magnitude of storage losses are determined by initial moisture at baling, storage facility or site (barn, stack, or plastic cover), type of ventilation, bale size and density, and length of storage. Hay should be baled and stored at 20 percent MC. Storage loss increases markedly when MC exceeds 22.5 percent moisture. Baling and storing hay with relatively high moisture will result in heat production by continued plant respiration. Sufficient moisture and oxygen encourage thermophilic microbial activity and chemical oxidation of plant tissues with a potential for spontaneous combustion.

Safe baling MC of 20 percent or less is a must. But, if hay can be baled at 25 to 30 percent MC, losses can be reduced significantly. Effective hay preservatives should control harmful organisms on hay for duration of storage. Preservation products act as fungicides and inhibit growth of microorganisms which cause heating and molding in wet hay (Table 5).

PRODUCING QUALITY SILAGE

Silage continues to be a popular method to store forage. Silage has the following advantages: more nutrients per acre preserved (Figure 2), less problem with unfavorable weather, mechanization of feeding, reduced field losses, and minimum labor needs.

Top quality silage is a product of a controlled fermentation (Figure 3). Carefully examine Figure 3 as it explains when silage is successfully stored, if additives or preservatives are needed, and ways of minimizing storage losses. The sooner phase 4 is reached, the lower losses will be. Management factors that will contribute to quality silage include: harvest at optimal forage quality and maturity, chop at 1/4 to 3/8 inch theoretical length for compaction, exclude air (oxygen), ensile at the correct moisture content for the forage and storage unit, and distribute evenly in the silo and seal. The nutritive value of various silages are presented in Table 6.

The use of or merits of silage additives, preservatives, or conditioners in making silage must be evaluated on its effect on the fermentation process. The major factors affecting the silage making process are type of forage, moisture content, buffering capacity, water soluble carbohydrate content, fineness of chop, and type of storage structure. Silage additives, preservatives, and/or conditioners are presented in Table 7. The benefits of preservatives and additives must be measured by the preservation of nutrients, change in acceptibility and finally in silage merit for feeding dairy cattle.

Table 1. Nutritive Components of Forages

Component	Availability	Factors limiting animal utilization
Cellular contents		
Soluble carbohydrate	100%	Intake
Starch	90+	Passage and intake
Organic acids	100	Intake and toxicity
Protein	90+	Fermentation
Pectin	98	Fermentation
Plant cell wall		
Cellulose	Variable	Lignification cutinization, and silicification
Hemicellulose	Variable	Lignification, cutinization, and silicification
Lignin, cutin and silica	Indigestible	Limit use of cell wall
Tannins and polyphenols	Limited(?)	Inhibit proteases and cellulases

Source: University of Illinois

Table 2. Alfalfa Quality and Stage of Maturity

Stage of maturity	Composition			Digest. dry matter	DMI % DW[a]	4% FCM lb/day[b]
	CP	ADF	NDF			
Pre bloom	21.1	30.2	40.5	62.7	2.08	87.1
First flower	18.9	33.0	42.0	61.6	1.97	77.2
Mid bloom	14.7	38.0	52.5	54.8	1.48	66.2

[a] With 20% concentrate.

[b] With 54% concentrate.

Source: University of Wisconsin

Table 3. National Weather Service Quidelines for Forecasting of Curing Times

RH	Windspeed	Curing time
%	mph	hours
<40	10-15	20-24
40-50	10-15	25-30
50-60	10-15	30-36

Source: National Weather Service

Table 4. Influence of Chemical Drying Agents That Hasten Drying of Cut Alfalfa

Treatment	Time to 75% DM (hours)
None	Over 51
Potassium carbonate (K_2CO_3)	34
Metyl ester + emulsify	38
K_2CO_3 + methyl ester & emulsifying agent	21

Source: Michigan State University

Table 5. Hay Preservatives

<u>Acetic-propionic acid mixtures</u>

1. Action
   Hay preservative, mold inhibitor
2. When: At baling
3. Level: 20-25% moisture 10 pounds per ton
   25-30% moisture 20 pounds per ton
   30-35% moisture 30 pounds per ton
4: Cost: .55 cents per pound
5. Recommendation: Yes.

<u>Sodium diacetate</u>

1. Action
   Inhibiting mold growth, decreasing temperature
2. When: At baling
3. Level: 4-5 pounds per ton
4. Cost: Varies
5: Recommendation: No scientific evidence to prove sodium diacetate is effective in preserving hay.

<u>Anhydrous ammonia</u>

1. Action
   Hay preservative, mold inhibitor
2. When: Treated in stack after baling.
3. Level: 1% when hay is 25% moisture
4. Cost: 12 cents per pound
5. Recommendation: Yes (safe to use on low quality forages)

<u>Bacterial inoculants</u>

1. Action
   Inhibit mold growth by producing propionic acid
2. When: At baling
3. Level: 10 to 30 pounds per ton (Propionic acid) needed to inhibit mold.
4. Cost: $1.50 - $3.00 per pound.
5. Recommendation: No scientific evidence to prove inoculants are effective in preserving hay.

Source: University of Wisconsin.

Table 6. Nutritive Value of Various Forage Silages

Forage silage	On dry matter basis, %					
	Dry matter	TDN	Protein	ADF	Ca	P
Corn silage	35	70	8.2	25	0.28	0.20
Alfalfa haylage (early)	50	57	18.5	30	1.25	0.23
Alfalfa hyalage (late)	50	57	16.0	34	1.28	0.20
Grass-legume haylage	50	54	15.5	33	1.52	0.37
Oatlage	50	59	9.7	32	0.37	0.30
Forage sorghum	35	56	7.7	35	0.30	0.24
Grain sorghum	35	57	7.3	26	0.25	0.18
Sudangrass	30	59	5.6	35	0.64	0.23

Source: University of Illinois

Table 7. Silage Additives, Preservatives and/or Conditioners

Fermentation Stimulants: Active Ingredients Common to Fermentation Aids

INGREDIENT	1. ACTION
Lactic acid bacteria	Lactic acid production
Homofermentative:	
Lactobacillus acidophilus	
L. Plantarum, L. Casei	
Streptococcus lactis	
S. Faecium, S. Cremoris	
S. Diacetylactis	
Pediococcus	
Heterofermentative:	
L. Brevis, L. Buchneri	
Other bacteria	
Bacillus subtilis	Butanediol fermentation
Bifidobacterium bifidum	Starch breakdown (enzymes)
Fungus	
Aspergillus oryzae	Starch breakdown (enzymes)
Yeast	
Torulopsis	Ferment sugars
Saccharomyces	Weak fermentation capacity
Enzymes	Cellulose (Breakdown cellulose) Protease (Breakdown protein) Amylase (Breakdown starch)
Trace minerals	Enzyme cofactors, microbial growth factors
Fermentation products	Source of B - vitamins and enzymes

2. When
   1) Where wet forages are ensiled (corn silage with less than 30% DM and alfalfa with less than 40% DM).
   2) Where forages are stored in trench or bunker silo's.
   3) Where silage life is important (once-a-day feeding, particularly in hot weather).
3. Level of inoculant: (Mixtures of lactobacillus, streptococcus and/or pediococcus).
   Minimum of 100,000 viable organisms per gram of fresh forage
   1 pound per ton.
4. Cost
   $1.50 - $3.00 per pound
5. Recommendations: Yes (in above situations)

Fermentation stimulants

Nutritive additives, fermentation stimulants

Grains

Corn, barley, oats and milo

1. Action
Add carbohydrates, enhance fermentation.

2. When: Ensiling
3. Level: 10% grain to alfalfa silage
4. Cost: 4-6 cents per pound
5. Recommendation:
Yes, high moisture, high protein forage. Forage short on soluble carbohydrates.

Limestone

1. Action
Increase calcium content of corn silage, adds bases to prolong fermentation

2. When: Ensiling
3. Level: 1%
4. Cost: 3 cents per pound
5. Recommendation: Limestone treated silage appears to have little value for dairy cattle.

Molasses

Sugar-beet and sugar-cane

1. Action
Increase DM and lactic acid contents, reduce pH

2. When: Ensiling, crops low in soluble sugars (Legumes)
3. Level: 5% (maximum benefit)
4. Cost: 7-8 cents per pound
5. Recommendations: Small savings in nutrients does not appear to justify the cost.

Whey

By product of cheese making

1. Action
Readily fermentable carbohydrate buffering by minerals.

2. When: Ensiling
3. Level: 1 to 2%
4. Cost: 12-14 cents per pound
5. Recommendation: Use on high moisture, high protein forage. Dry versus liquid, liquid added to reconstitute baled hay.

Fermentation inhibitors: acids and others

Mixture Hydrochloric and Sulphuric Acids

1. Action
Lower pH of forage at which plant and microbially enzymes would be inhibited (pH 3.0).

2. When: Ensiling
3. Level: .5%
4. Cost: Varies
5. Recommendation: No, corrosive and may cause problems in application handling equipment, silo walls and person.

Formic Acid

1. Action
Decrease pH, limit fermentation, direct acidification.

2. When: Ensiling, direct-cut silages
3. Level: Direct cut (20% DM) = .3% per ton
   wilted silage (35% DM) = .6% per ton
4. Cost: Varies
5. Recommendation: Yes (silages, also used with corn, wet brewers grain).

Antibiotics
Zinc bacitracin, others

1. Action
Inhibit or depress putrifactive spore forming bacteria

2. When: Ensiling, early stages of maturity (effective only with low DM silage)
3. Level: 10 grams per ton
4. Cost: Varies
5. Recommendation: No, both lactic acid and clostridia are gram positive. Inconsistent effect on silage.
   Potential milk residue

Sodium Chloride

1. Action
Food preservation

2. When: Ensiling
3. Level: 1% per ton
4. Cost: 3 cents per pound
5. Recommendation: No, salt does not inhibit growth of molds or improve forage quality.

Nutritive additives - Aerobic inhibitors

Propionic acid

1. Action
Preservation, reduce yeast growth, prevent temperature rise.

2. When: Grain and ensiling forage (50% DM)
3. Level: Grain 20% moisture = .75%
   25% moisture = 1.0%
   30% moisture = 1.25%
4. Cost: 55 cents per pound
5. Recommendation: Yes. Retards aerobic fermentation of silage during feeding. Corrosive to equipment and person. Propionic acid used on grain. Acetic-propionic used on forages.

Source: University of Wisconsin

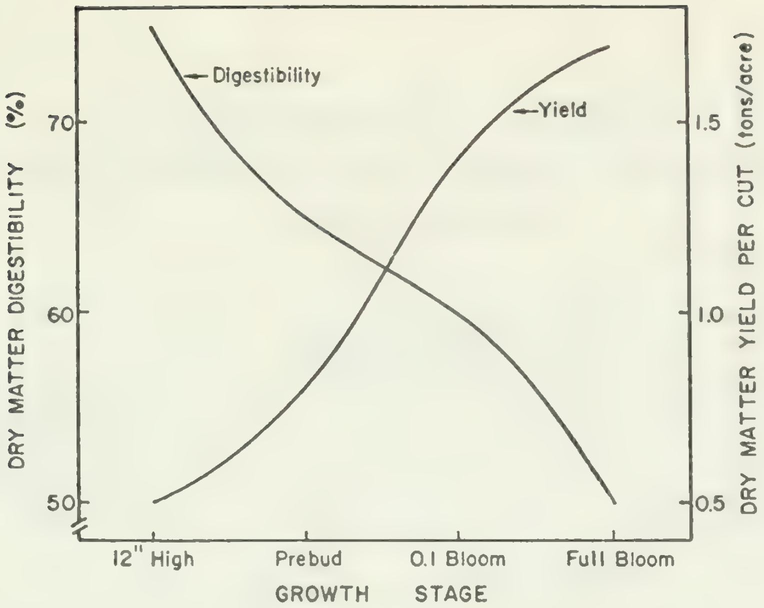


Figure 1. Relationship Between Dry Matter Digestibility and Yield at Different Stages of Alfalfa

Source: Virginia Polytechnic Institute

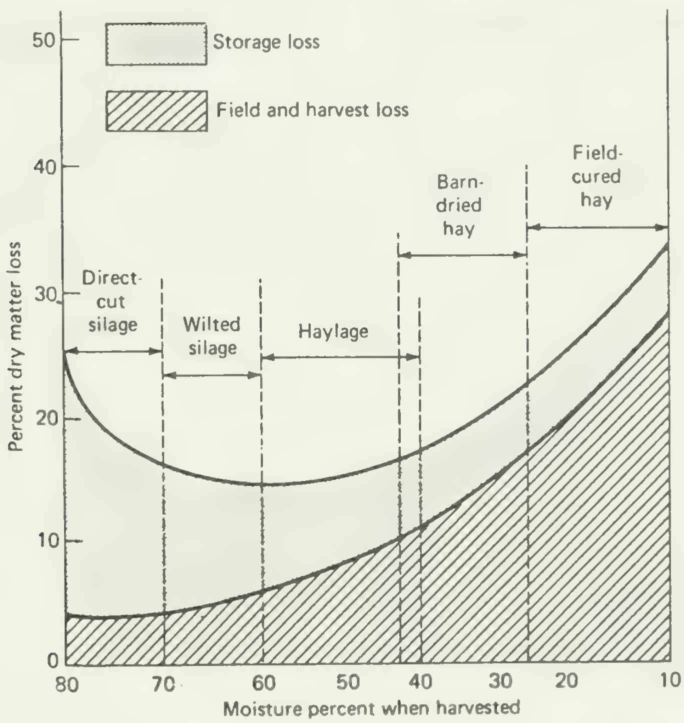


Figure 2. Losses in Legume-grass Forages at Various Moisture Levels

Source: Michigan State University

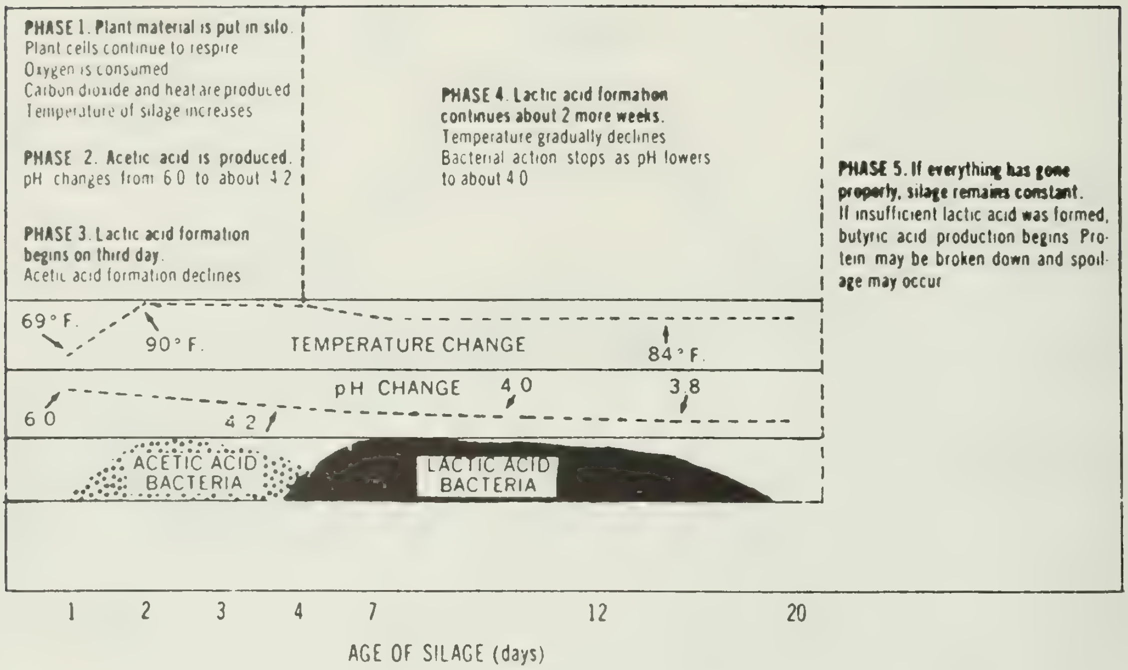


Figure 3. Schematic Diagram of a Normal Fermentation Process

Source: Iowa State University

Environmental Mastitis: Characteristics and Control Strategies

R. David McQueen

Mastitis (inflammation of the mammary gland) is caused primarily by bacterial infection. Bacteria enter the gland through the teat canal. Clinical mastitis is usually readily observable because of changes in the udder (painful, hot, swollen quarter(s) in acute cases), changes in milk appearance (flakes, clots, watery appearance) and reduced milk yield. Subclinical mastitis is a form of infection that causes no readily detectable changes in the udder or milk, yet causes an increase in somatic cell count (SCC).

The bacteria that most frequently cause mastitis can be divided into two groups based on the source of the bacteria.

BACTERIA CAUSING CONTAGIOUS MASTITIS

Milk from the udder of cows with contagious mastitis is the principal source of the causative bacteria (<u>Strep. agalactiae</u>, <u>Strep. dysgalactiae</u> and <u>Staph. aureus</u>). <u>Strep. ag.</u> and <u>Staph. aureus</u> are well adapted to attach to and colonize the teat canal/udder gland, thus establishing subclinical infections of long duration (i.e., lasting through one or more lactations). <u>Strep. dysgalactiae</u> colonizes the teat canal/teat skin lesions/udder gland but usually causes an acute udder infection shortly after invading the gland. Thus it is more often treated and eradicated than <u>Strep. ag.</u> and <u>Staph. aureus</u>. All three bacteria may be spread from infected quarters to uninfected quarters of the same and other cows by transfer of milk from infected quarter(s). Objects that may transfer milk and therefore these bacteria are: 1) contaminated milking machine units, 2) re-used udder wash cloths/towels and 3) the hands of the milking machine operator. The feeding of milk/colostrum from an infected cow to calves may also establish prolonged infection of the tonsils. The infection may then be spread from one heifer to the teats of others which are nursed by the infected heifer. A contagious mastitis control program should include post-milking teat dipping with an effective germicide, dry treatment of all quarters of all cows, lactational treatment of clinical flare-ups, proper milking, culling of treatment failures, and a milking order when feasible and necessary to achieve the desired level of control.

BACTERIA CAUSING ENVIRONMENTAL MASTITIS

Bacteria that are commonly present in the cow's environment reach the udder/teat end by physical contact between the cow and the sources. This fact dictates different control measures for mastitis caused by the environmental bacteria than for mastitis caused by contagious bacteria.

Two groups of bacteria account for most environmental mastitis infections: 1) coliforms and, 2) environmental streptococci (i.e., streptococci species other than <u>Strep. ag</u>. Generally, environmental mastitis infections in any given herd are caused by a variety of bacteria, a reflection of the diverse bacterial species inhabiting various objects in the environment. Also, a bacterial specie may consist of several strains, each varying in its ability to

cause mastitis, adding to the difficulty of designing control programs. In typical E. coli herd outbreaks involving several cows, several E. coli strains are usually involved. If technologic breakthroughs ever make possible the production of an effective E. coli vaccine, strain differences may limit commercial usefulness.

Additional types of environmental bacteria may occasionally cause mastitis; i.e., Pseudomonas, Serratia, Bacillus and Proteus. Pseudomonas is noteworthy because of its' ability to grow in milk house water systems, especially low iodine udder wash water remaining in copper water lines and parlor drop hoses. Free iodine levels in such water are often less than 25 p.p.m., permitting growth of bacteria. Table 1 lists the principal environmental bacteria and their sources.

The pronounced seasonal pattern of infections caused by environmental bacteria usually differs from the year round pattern of infections caused by contagious bacteria. However, it is seldom possible to identify the cause of a flare-up in an individual cow by visual/physical changes in the udder/milk.

Environmental mastitis infections tend to be of short duration, because the bacteria do not colonize the teat canal and they are relatively susceptible to destruction by leucocytes in the udder. About 60 percent of such infections last less than ten days. Thirteen percent of coliform (1.5 percent of E. coli specifically) and about 18 percent of Strep. sp. infections (especially Strep. bovis and Strep uberis) last longer than 100 days. Generally 5-10 percent of quarters in a herd are infected by environmental bacteria, compared to 25-75 percent infected quarters in herds with moderate to severe contagious mastitis infection.

Eighty to 90 percent of coliform and 50 percent of Strep. sp. quarters infected during lactation will result in clinical signs of mastitis. In most cases the infection is characterized by clots or flaky milk and little to moderate udder swelling lasting only a few milkings. Most infections do not cause the cow to go off-feed or show other systemic signs. However, many dairymen and some veterinarians relate environmental mastitis only with the 8-10 percent of coliform infections that are acute or peracute, i.e., cows showing severe systemic symptoms/death. Peracute coliform mastitis is seen most frequently: 1) in older cows, 2) during early lactation and 3) during periods of hot, humid weather lasting several days. Such infections may cause death, loss of a quarter, or a marked decrease in production for the remainder of the lactation. A decrease in ability of the periparturient older cow to mobilize leucocytes rapidly in coliform infection is a predisposing factor (see Fig. 1).

The seasonal increase in environmental udder infections and the associated potential increase in herd somatic cell count (SCC) should be of concern because it may result in the loss or reduction of milk quality bonus payments. It is important to look beyond the obvious clinical mastitis cases and determine what type of infections are contributing most to the herd SCC. In a herd whose SCC has risen gradually or is persistently above 500,000, a major portion of the count is most likely due to subclinical udder infection caused by contagious bacteria. Herds with low rates of contagious mastitis may experience an increase of 100,000 to 300,000 in SCC during the warmer months of the year. This increase is often caused by increased numbers of intermittent

subclinical environmental mastitis infections, punctuated perhaps with periods of severe coliform mastitis affecting older early lactation cows.

The seasonal nature of environmental infections is directly related to exposure to rapidly multiplying environmental bacteria during warmer, more humid weather. Bacteria require heat, moisture and nutrients to multiply. Thus, the requirements of contagious bacteria living in the teat canal or udder gland are continuously met (i.e., milk at body temperature), and thus new contagious infections tend to occur year round. The numbers of environmental bacteria in bedding, however, decline in the cool dry and frigid temperatures of late fall-winter on midwestern dairies.

The economic loss factors associated with contagious mastitis differ from those due to environmental mastitis. Contagious mastitis bacteria (<u>Strep. ag.</u> or <u>Staph. aureus</u>) persist year round and are spread cow to cow. Losses are primarily due to: 1) decreased production by quarters with persistent subclinical infection , 2) milk discard and treatment costs of clinical flare-ups, 3) loss of milk quality premium payments, 4) high SCC price penalty assessed by certain processors, and 5) premature culling. The magnitude of the total loss is directly related to the percent of cows/quarters infected and the herd SCC. Losses due to environmental mastitis are primarily due to: 1) loss of milk quality premium payments (elevated herd SCC; standard plate and pre-incubation count may also be increased), 2) milk discard and drug treatment costs of clinical flare-ups, 3) pre-mature culling and 4) death from peracute coliform mastitis. Losses peak seasonally and are usually attributed to a low percent of the cows, especially cows in early lactation. Herd subclinical environmental mastitis infections are frequently the major deterrent to milk quality bonus payments in low SCC herds with a low incidence of contagious mastitis.

The implications of the preceding factors to herd monitoring methods, such as interpretation of individual cow CMT or SCC, bacteriological cultures, and SCC reduction management procedures are very important. Bulk tank and individual cow SCC/CMT scores are excellent measures of the progress/success of contagious mastitis control/reduction programs. A single elevated bulk tank or individual cow SCC, however, indicates only the presence or recent presence of udder infection, but does not indicate the type infection.

Monthly bacterial culture of bulk tank milk has been suggested by some as a way to monitor and identify herd mastitis infections. Bulk tank milk culture is moderately accurate in estimating the herd incidence of <u>Strep. ag.</u> and <u>Staph. aureus</u> because these infections are persistent and cause gradual changes in SCC in infected herds. The short duration of most environmental infections and rapid weather related changes in exposure to environmental bacteria severely limit the accuracy or predictive value of bulk tank milk culture for environmental infections. Also, high numbers of environmental bacteria in bulk tank milk may be indicative of poor teat cleaning/sanitation and thus milking time exposure rather than actual environmental udder infections.

Bacterial culture of sanitarily collected milk from CMT(+) quarters is needed to identify the bacterial cause(s) of mastitis in individual herds. Generally, environmental bacteria, contagious bacteria or both can be the cause of elevated SCC/CMT(+) quarters in low SCC (<500,000) herds. However, as many as 30-40 percent of milk samples from CMT(+) quarters may contain no mastitis

bacteria. This is usually not an indication of poor lab technique; rather, it is a reflection of the fact that about 60 percent of Strep. sp. infections are cured spontaneously, and the fact that bacterial numbers are reduced below detectable levels in most E. coli infected quarters within 24-36 hours after onset of clinical signs.

A major limitation to quarter milk culture in environmental mastitis problem herds is inadequate preparation of the teat end prior to milk sample collection. Teat end bacteria of environmental origin can not be differentiated from those inside a gland infected with environmental bacteria. Thus contamination can lead to false conclusions, particularly in pooled samples containing milk from all four quarters.

CONTROL MEASURES FOR ENVIRONMENTAL MASTITIS

1. Improve Sanitation

Confined cows are at greater risk of environmental mastitis than cows on well drained pastures because of greater exposure to sources of environmental bacteria; i.e., feces, bedding material, dirt, mud and water. Also, the natural drying action and ultraviolet (sunlight) destruction of bacteria is reduced or absent in confinement. Contaminated bedding materials are a major factor in teat end exposure to environmental bacteria. The number of bacteria in any given bedding depends on: 1) the nutrients in the original bedding plus the nutrients added to bedding (i.e., milk leakage), 2) the amount of bacterial contamination (feces), 3) the bedding moisture level (increased by urine, damp manure, calving fluids, humid air) and 4) temperature (see Fig. 2). High humidity also reduces evaporative drying of soiled bedding and thus favors increased bacterial growth. Bacterial growth also produces heat and moisture, favoring continued growth. Improperly sized or constructed free stalls and tracking of manure from alleys increases contamination of the bedding at the rear of stalls. Thus, daily bedding replacement in the back one-third of the stall and twice daily alley cleaning reduces exposure of the teat end to coliform and Strep. sp. bacteria. There are reports of increased Klebsiella mastitis with sawdust bedding, including several Illinois herds. A recent Ohio study, however, found higher and approximately equal numbers of Strep. sp. and coliforms in straw and sawdust bedding in a ten farm survey. Inorganic beddings (sand, limestone) support lower bacterial populations of all three types of bacteria, probably due to lack of nutrients and lower moisture content (2-5 percent vs. 30 percent moisture for slightly soiled straw/sawdust).

In summary, exposure to environmental bacteria can be reduced by improved sanitation:

1. Reduce over-crowding in stalls and lots to reduce feces/urine load in alleys/housing.

2. Improve building ventilation to reduce moisture, enhance evaporative drying, and reduce stress on cows.

3. Remove manure daily or more frequently from the back of stalls, alleyways, exercise lots and feeding areas.

4. Drain, fill or fence off low wet areas in lots and pastures. Build mounds in lots with less than 3-8 percent slope.

5. Eliminate access to farm ponds.

6. Maintain free stalls properly. Consider stall dividers and car tire installation to improve stall comfort and reduce hole digging. Install breech boards to reduce soiling of bedding adjacent to the curb.

7. Improve heifer pen and maternity pen sanitation to reduce new infections in the pre-calving period.

2. Postmilking Feeding

Minimizing teat end exposure to environment bacteria for 30 minutes after milking is extremely important because the teat sphincter muscle is exhausted and closure of the teat canal takes 15-30 minutes. Limited experimental evidence suggests that a small droplet of milk often remains within the teat canal and may serve to transport teat end bacteria through the teat canal, especially in humid weather. When drying of the droplet is slow, rising fat globules may assist colloidal movement in transporting bacteria in the droplet through the teat canal. As few as 20 *E. coli* bacteria in the teat sinus may produce clinical mastitis. Feeding cows immediately after milking and reducing standing time in holding pens increases the percent of cows standing during the first 20-30 minutes postmilking.

3. Improving Pre-milking Teat Hygiene

Experimental exposure to *E. coli* immediately after milking produced a seven fold greater infection rate than exposure one hour pre-milking (see Table 2). Early field reports of pre-dipping benefits were thus viewed with skepticism by researchers. Limited pre-dip research has, however, demonstrated up to 40 percent reduction in new infections with pre-dip use following *Strep. uberis* exposure prior to milking. Pre-dipping has reduced herd SCC and mastitis flare-ups in commercial herds having significant environmental bacterial exposure and milking systems/procedures that are conducive to liner slips and other high velocity teat cup air admissions. Liner slips result in the impact of bacterial aerosols against or through the teat canal. This is the major way conventional milking machines influence new udder infection rates.

Pre-dipping provides limited benefit in reducing udder infection/high SCC caused by contagious bacteria (*Strep. ag.* and *Staph. aureus*), because milk containing these bacteria can be spread after pre-dipping when contaminated teat cups are put on non-infected cows. Herds with bulk tank SCC in the 100,000-200,000 range often have 1-5 percent of cows infected with contagious bacteria. Post-dipping with an effective dip is needed to reduce the rate of new contagious infection despite milking time exposure. The dip must penetrate the teat canal, the usual initial site of infection by contagious bacteria.

Most benefit derived from pre-dipping is due to reduction of teat skin bacteria numbers by the combined effect of vigorous wiping and increased

bactericidal action (see Table 3). The germicide content of an effective pre-dip is 25 to 400 times the strength of the same germicide used as an udder wash. Despite the additional germicide strength, pre-dip contact time of 45 second to 1 minute is desirable to insure at least a 75+ percent reduction in teat skin bacteria numbers. Contrary to popular belief, germicides do not kill bacteria instantly. The speed of germicidal action is reduced in dried material such as dirt and manure and at lower environmental temperatures. Thus, visible teat contamination should be removed prior to pre-dipping. In some herds, dipping has achieved striking improvement in herd SCC in part because the procedure: 1) eliminated "robo-wash" type udder wetting, and draining of contaminated water into teat cup mouthpieces and, 2) eliminated the milking of wet teats by adding teat drying to reduce germicide residue.

Procedure for Pre-dipping

1. If teats/udder are clean:

    a. Dip entire teat (especially important if teat lesions are present).
    b. 1 minute delay (necessary for high percent bacterial kill).
    c. Wipe dry 20 sec. with single use towel (stimulate let-down and remove residue).
    d. Attach unit 1 minute later or when let-down (teat distention) is visible.

2. If teats/udder are dirty:

    a. Wash teats only (warm water or mild detergent solution) and wipe vigorously to remove visible soil (stimulates let-down).
    b. Dip entire teat(s).
    c. 1 minute delay (necessary for high percent bacterial kill).
    d. Wipe dry rapidly.
    e. Attach unit immediately.

Comments

1. Use one teat cup for pre-dip and a separate one for post-dip. Wash inside and outside of teat dip cups after every milking and whenever dip is visibly contaminated.

2. Use the same germicide in pre- and post-dips to avoid chemical incompatibility (otherwise post-dip germicide residue on the teats may inactivate the pre-dip at the next milking).

3. Pre-dipping does increase the level of germicide residue in milk. Also, skin irritation may develop, especially on the milker's hands. Gloves may be worn or a change in dip may be required. The long term human effect of germicide absorption through the skin or lungs is not known. Iodine and chlorine both vaporize and can be inhaled, especially if sprayed. If teat dip sprayers are used, direct the spray, use minimal amount, and provide proper ventilation (air movement away from the person spraying).

Pre-dips (examples)

1. 0.1-0.25 percent Iodophor post-dip.

2. 50 percent up to full strength ChloroxR.

3. 0.5 percent Chlorhexidine post-dip.

4. Other proven effective non-barrier germicidal post dips with 75+ percent bacterial kill in 1 minute.

Calculations of the cost of pre-dipping should include: 1) cost of the dip (teat dip spraying increases dip use), 2) labor to apply dip and wipe teats dry, 3) increased electricity use and depreciation of vacuum system due to extended operation (fewer cows milked/hour). Detailed cost/benefit studies of pre-dipping have not been conducted, but logic suggests that pre-dipping may not be cost effective during cold weather when daytime/housing temperatures are consistently below 40oF and environmental bacteria populations are low.

4. Reduce Air Admission/Liner Slips

Minimize teat cup air admission during attachment; minimize liner slips by re-positioning the claw midway through milking; change to liners with less tendency to slip; leave all four teat cups attached, shut off claw vacuum and wait for unit to fall away naturally when detaching.

5. Feed Additional Selenium/Vit. E

Ohio research in dairy cattle by Conrad and Smith has confirmed the enhanced immune response seen in other species when the diet is supplemented with additional selenium and vitamin E (Figure 3).

Smith recommends that dry cows receive 1000 IU Vit. E (1 gm) and 3 mg selenium daily plus 10cc of MuSeR 21 days prior to calving; lactating cows should receive 400-600 IU Vit E and 6 mg selenium daily. Recently, FDA increased the permitted level of sodium selenite in dairy cattle feeds to provide 0.3 ppm selenium in the complete diet. Feed companies commonly add selenium "200" premix, (which contains 200 ppm selenium/kg, or 90.8 mg Se/pound, to the concentrate grain mix. For a high producing cow in early lactation, the ratio of forage dry matter to concentrate dry matter (D.M.) typically varies from 50:50 to 40:60. Assuming an average ratio of 50:50, 6# of Se "200" premix is added per ton of concentrate to provide 3 pound Se "200" premix per ton of total ration D.M. (0.3 ppm of added selenium in the total ration).

Several problems are inherent with this approach to supplementing dietary selenium:

1. Cows that consume different proportions of the same concentrate and forage have different total ration selenium concentrations; i.e., a 75:25 forage/concentrate ration (low producer) will contain 0.15 ppm selenium in the total ration D.M. while a 40:60 ration (high producer) will contain 0.36 ppm added selenium.

2. The amount of total diet consumed markedly influences the amount of added selenium actually consumed. If a 50:50 forage/concentrate ration is assumed, a 1400 pound cow eating 3.5 percent of her body weight (B.W.) in feed D.M. will receive 6.67 mg added selenium, but a similar cow eating 2.5 percent of B.W. will receive only 4.77 mg of added selenium.

3. A 1500 pound close-up dry cow fed 7.5 pounds D.M. of the same concentrate and 22.5 pounds of hay D.M. (75:25) will receive only 2.04 mg of added selenium. In order to provide the recommended amount of selenium to the close-up dry cow being fed limited amounts of concentrate, the forage/concentrate ratio must be known and the appropriate amount of Se 200 added to a concentrate formulated for dry cows:

Se in Total Ration D.M. 0.3 ppm

pounds Se 200 added/ton Conc.	Forage D.M./Conc. D.M.
30	90:10
15	80:20
9.9	70:30
7.5	60:40
6.0	50:50
5.4	40:60

4. Many variables influence the actual uptake of selenium from feeds. With 0.8 percent dietary calcium (normal lactating cow diet), 40-50 percent of dietary selenium is absorbed; with 0.4 percent dietary calcium (milk fever preventive dry cow diet) about 25 percent of selenium is absorbed; at 1.2 percent calcium about 25 percent is absorbed.

5. Clinical selenium deficiency symptoms in dairy cattle are customarily considered to be white muscle disease and retained placenta. Additionally, increased incidence of cystic ovaries, metritis, abortion, and reduced first service conception rate have recently been reported with selenium and/or Vitamin E deficiency. Leukocytes of Se-Vit E treated animals have also shown significantly greater kill of engulfed bacteria, (Staph. aureus and Candida albicans in cattle) and increased attraction to bacterial toxins and waste products.

Many feed companies are now adding up to 3 times more selenium to various commercial products than previously. Be sure to calculate total selenium intake before top dressing Se 200 pre-mix if commercial concentrate or grain mixes are being fed. Selenium toxicity may develop if cows receive more than 2 ppm in the diet. Signs include cracking of hooves, lameness, stiffness of joints, body weight and hair loss.

Concerns are still being expressed today about the carcinogenic potential of selenium, despite no evidence to that effect. The only documented long term human health problem due to selenium overexposure is one area of China with

endemic human selenosis due to soil contaminated with high selenium weathered coal, with selenium entering the food chain. On the contrary, recent evidence indicates selenium supplementation may inhibit both chemical- and viral-induced tumor growth.

The diagnostic laboratory at Urbana routinely performs selenium analyses of whole blood and feed samples (3 samples/$30.00 plus $3.00 each additional sample for Illinois residents).

Whether the benefits of pre-dipping and selenium/Vit E addition are additive and cost effective when used in combination has not been determined.

6. Follow The 5-Step Contagious Mastitis Control Program

Post milking teat dipping with an effective germicidal dip is advised, although the procedure affords only limited control of environmental Strep. sp. and no reduction of coliform infection. Barrier (sealer) dips are sometimes advised to reduce new coliform infections. The effectiveness of barrier dips against Strep. ag., Staph. aureus and Strep. sp. is less than germicidal non-barrier dips, and their continued use in herds with such infections is not advised. Dry period teat dipping has been of limited value in reducing new Strep. uberis infections because it is labor intensive and standard commercial teat dips lack the desired residual action.

Dry cow treatment of all cows at dry-off is advised to cure existing Strep. uberis/Strep. bovis infections and to reduce new Strep. sp. infections, especially in the early dry period. Dry cow infusions does not reduce coliform and new Strep. sp. infections in the late dry period because an adequate level of antibiotic is not maintained during this period of increased susceptibility. Thus, improving housing sanitation and providing added Se-Vit. E for close-up dry cows are strongly recommended.

Lactational therapy of clinical environmental mastitis is necessary to reduce the SCC to marketable levels in acute cases, even though bacterial cure rates of Strep. sp. is about 50 percent and much less for Strep. uberis and Strep. bovis infections. Relapses in Pseudomonas, Serratia, and Bacillus cereus infections following treatment are common, and such cows should be culled. Despite a high rate of bacterial clearance in acute E. coli infected quarters, most fatal mastitis infections are caused by E. coli (see Table 4). This is because dead and dying E. coli release potent toxins that can cause severe shock and a drop in blood calcium, leading to milk fever like downer cow symptoms.

The key to successful treatment of clinical environmental mastitis cases is early detection, early and continued body temperature monitoring and observation, and early therapy for cows showing systemic symptoms (temperature elevation, off feed, depression, weakness). Treatment of mild flare-ups which often self-cure results in unnecessary drug use and milk discard. Such cows typically are not off-feed and only fore-milk contains a few flakes. The udder is only moderately swollen, which improves by the subsequent milking. Early detection and continued monitoring of such quarters/cows allows the experienced dairyman to correctly identify a high percent of the self-cure mild clinicals, thereby, minimizing drug usage and milk discard losses. Intensifying sanitation efforts on the high risk close-up dry cows and heifers and early

lactation mature cows reduces the occurrence of acute environmental mastitis flare-ups.

COAGULASE (-) STAPH SP. (CN STAPH)

The CN staph bacteria are sometimes referred to as the "Staph. non-aureus" or as "minor pathogen group". These staph are intermediate in virulence and toxin production between contagious Staph. aureus and the previously discussed environmental bacteria. CN staph typically colonize the teat skin and teat canal and thus are frequently isolated from milk. Staph. epidermitis is frequently found in herds that are not teat dipped. Invasions of the udder by some CN staph strains results in a moderate SCC elevation and decrease in production. New udder infections often develop in close-up pregnant heifers and cows, persisting into or through the subsequent lactation. Infection rates usually decline in lactating heifers and cows with continued use of germicidal teat dip (see Fig. 3).

A shift in infection rates between species of CN staph. has also been observed following iodophor, chlorhexidine and linear dodecyl benzene sulfonic acid teat dip use. Pre-dipping has not been shown to reduce CN staph infection rates. Lactational therapy usually cures about two thirds of the acute infections with accompanying reduction of SCC in about three weeks.

In some well managed herds, CN staph are the most common cause of udder infection, but may cause only a small percent of the clinical flare-ups (Table V). Dry cow therapy eliminates almost all gland infections, especially when partial teat tube insertion methods are used. There is, however, a high rate of new infection in the last half of the dry period (see Fig. 4). The gradual reduction in infection rate in lactation following continuous teat dip use suggests that daily teat dipping of the close-up heifer/cow may be of benefit, providing the entire teat skin is covered with germicide. The cost/effectiveness of this procedure in reducing CN staph infections has not been adequately researched.

Table 1. Environmental Bacteria Able to Cause Mastitis

Bacteria	Source	Possible associated factors
E. coli	Feces.	Wet unhygienic bedding and buildings. Dirty cows. Poor hygiene in calving boxes. Sanitation and/or mechanical faults with milking equipment.
Other intestinal bacteria Enterobacter sp. Citrobacter sp. Serratia sp.	Feces.	Similar to E. coli but less common in occurrence. Usually sporadic mastitis cases as part of a general 'environmental' problem. May contaminate milking equipment.
Streptococcus uberis	Feces. Cow skin, tonsil, vagina, and soil. Contaminated bedding.	Similar to E. coli. Survives well and multiplies in wet, dirty bedding. Clean long straw often contains more streptococci than coliform bacteria.
Strep. species	Feces.	Strep. bovis is notable as the major starch digester bacterium in the rumen. Heavy grain feeding may increase fecal bacterial numbers.
Klebsiella pneumoniae	Feces. Bedding material. Widely distributed in nature.	Has been shown to multiply in sawdust and in wet baled straw. Stored bedding must be kept dry. May contaminate milking equipment.
Bacillus cereus	Spores widespread. Found in cattle feces.	Outbreaks have been associated with brewer's grains where levels of 4x108/g have been recorded. Infection probably from feces-contaminated bedding. Has been associated with contaminated intramammary products.
Pseudomonas aeruginosa	Soil and water. Feces.	Can multiply in water supplies, particulary udder-wash systems. Can accumulate on poorly cleaned milking equipment. An association with contaminated udder infusion tubes has been described.

Table 1 (cont.). Environmental Bacteria Able to Cause Mastitis

Bacteria	Source	Possible associated factors
Corynebacterium pyogenes	Lesions with pus.	Associated with 'Summer mastitis' in conjunction with Str. dysgalactiae and anaerobic bacteria. Sporadic cases occur throughout the year.
Rapid-growing, acid-fast bacteria	Environment.	Unhygienic intramammary infusion. Association with oil-based udder infusion tubes.
Yeasts		
Cryptococcus neoformans	Environment.	Has been found in contaminated udder infusion tubes.
Candida sp.	Environment.	May gain entry due to unhygienic intramammary infusion. Candida kruzei has been found in large numbers in poorly-stored, wet sugar beet pulp.

Table 2. E. coli Timing and Challenge Results

E. coli contamination	Proportion infected		
	Front	Hind	Total
1 hour prior to milking	2/20	0/20	2/40
Immediately after milking	3/20	11/20	14/40

--Bramley: NMC, 1985

Table 3. The Efficiency of Washing Methods in Removing Staphylococcus aureus from Teats Contaminated Artificially

Treatment of Teats	Recovery of Staph. aureus
Foremilk taken, no wash	23,000
Mains water spray (15s)	7,940
Water wash, bucket, paper	1,790
Water wash, bucket, cloth	1,630
Water wash, hose, hand	630
Chlorine wash, bucket, paper	937
Chlorine wash, bucket, cloth	128
Chlorine wash, hose, hand	69

--NIRD

Table 4. Deaths - Mastitis (culture positive quarters)

		percent
E. coli.	107	82.3
Klebsiella	12	9.2
Staph. aureus	11	8.5
TOTAL	130	100%

--Guelph/Ontario Vet. Col.
Diagnostic Laboratories, 1984

Table 5. Clinicals in Low SCC Herds (10)

CN Staph	6%
Strep Sp	23%
Coliforms	37%
Staph. aureus	1%
No growth	29%

--Larry Smith, OARDC 1987

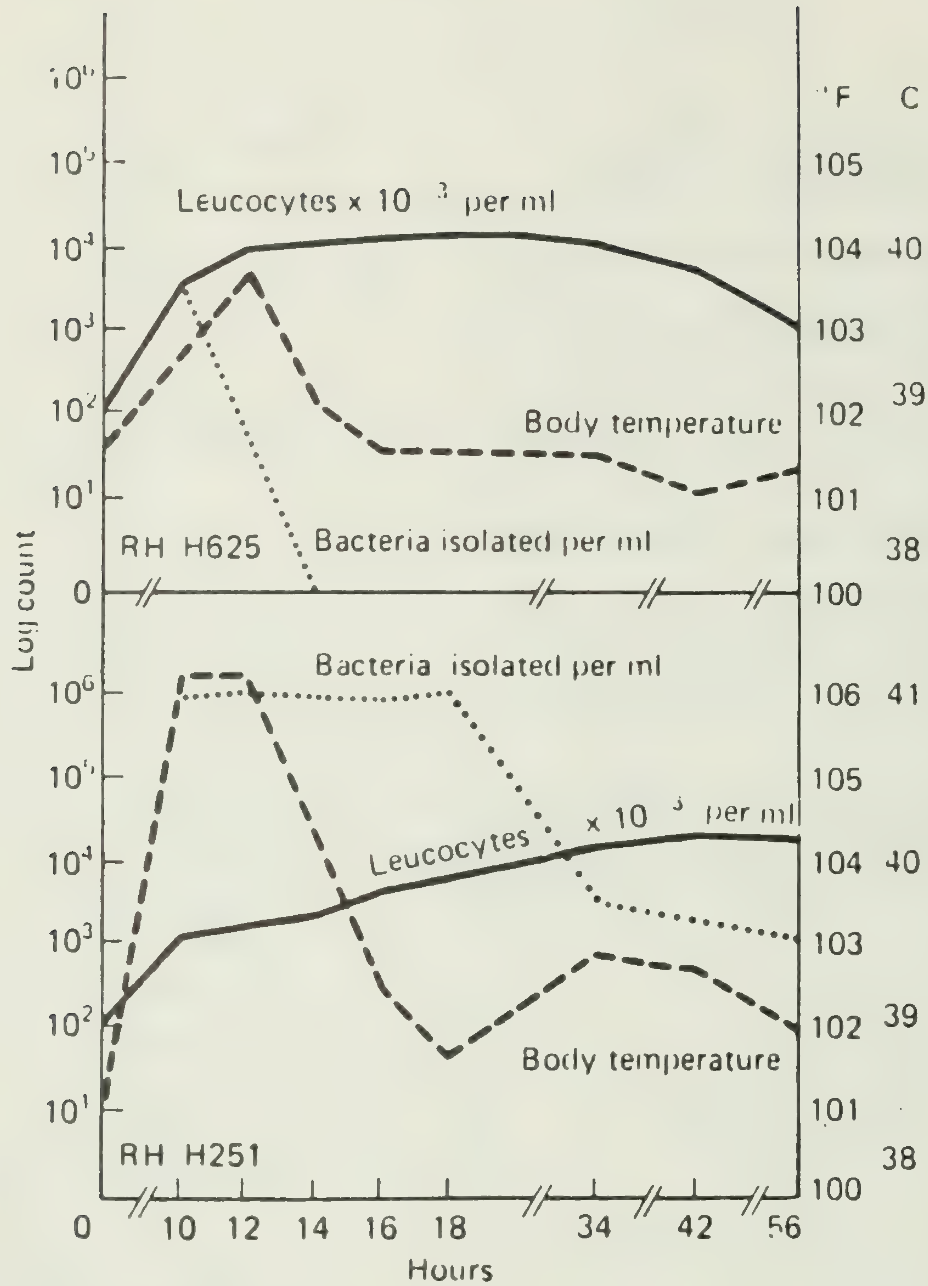


Figure 1. *A comparison of the response of a single mammary quarter of a newly calved cow (H251) with that of a mid-lactation cow (H625) to infection with 10^3 E. coli.*

--Hill et. al., 1979

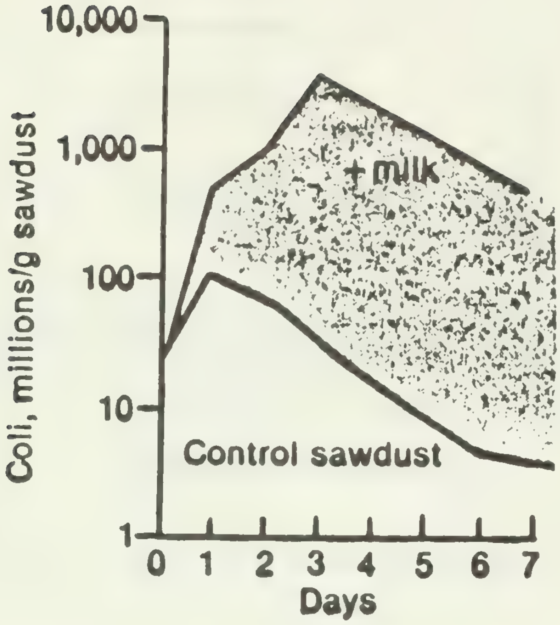


Figure 2. Growth of E. coli in sawdust added to free stalls with and without milk (leakage).

--NIRD

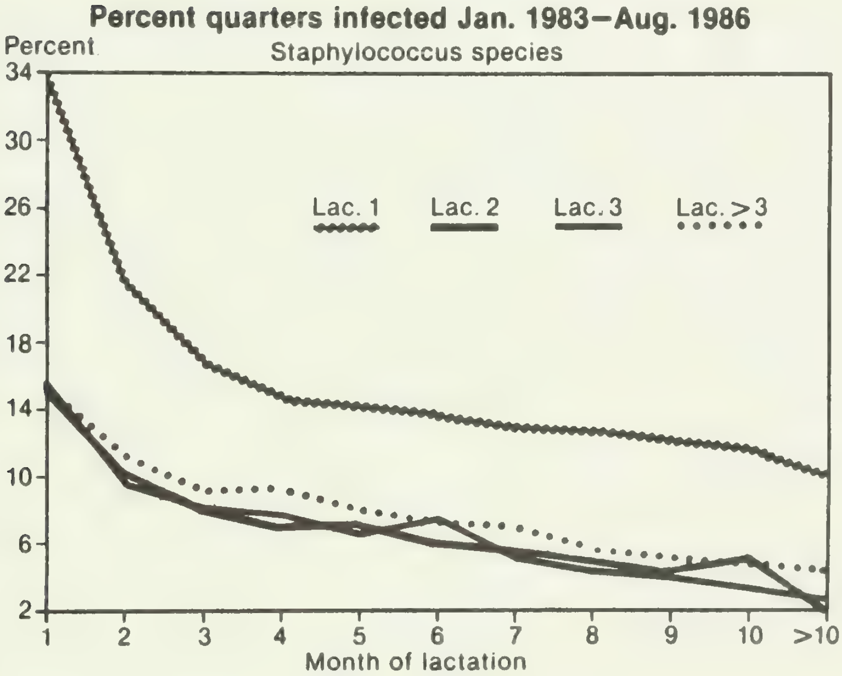


Figure 3. J. Hogan, OARDC 1987

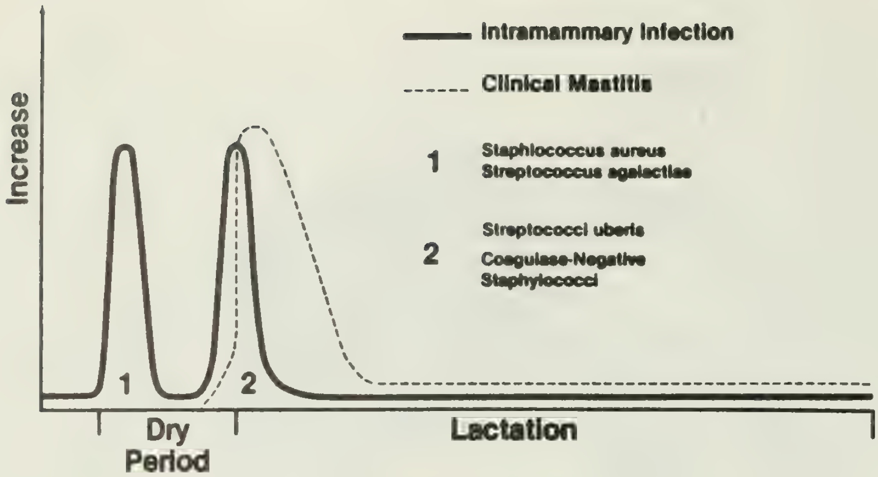


Figure 4. Incidence of new mastitis infections.

University of Illinois
Research Reports

Dairy Energy Use and Conservation

Ted L. Funk

Studies of energy use on dairy farms estimate that it takes between 3.8 and 5 kilowatt-hours of electricity to produce a hundredweight of milk. Midwest dairy farms raising their own corn and forages also use about one-third of a gallon of liquid fuel (gasoline equivalent) per hundredweight of milk. Together, electricity and liquid fuel contribute $.40 to $.85 per hundredweight to the cost of milk production, assuming today's energy prices.

An energy audit of a large number of dairy farms by the Cooperative Extension Service of the University of Vermont in 1979-80 suggested that, for typically-sized dairy operations, a breakdown of the largest energy-consuming activities would look like this:

Activity		Consumption per cow-year
	Forage production	12.5 to 13.5 gal.
Liq. fuels	Corn production	about 26 gal.
	Manure hauling (solid, daily spread)	11 to 14 gal.
	Milking	82 to 98 kwh
Elec.	Milk cooling	about 150 kwh
	Water heating	175 to 275 kwh

ELECTRICAL ENERGY

The "big three" items in electrical usage on the farm are water heating, milk cooling, and milking machine operation. Here are some practical ways to cut kilowatt-hours:

Maintain Cooler Condenser

If your milk refrigeration unit has an air-cooled condenser, keep the condenser clean and its airflow unrestricted. Poor airflow can raise the operating temperature of the condenser the equivalent of a 10- to 20-degree rise in the ambient temperature, requiring about 10 to 20 percent more electrical energy.

Install a heat exchanger

A properly-sized heat exchanger can cut energy bills by heating water with the "waste" heat from your milk cooling system condenser. In choosing a heat exchanger, estimate your farm's daily hot-water use as closely as possible, and match your daily milk production to the system. Careful sizing will prevent your buying a heat exchanger that has to dump a lot of unneeded hot water down the drain, or a low-efficiency model that doesn't deliver enough hot water to make the installation worthwhile.

See the Illini Dairy Guide #17 "Milk Cooler Heat Exchangers for Heating Water," for more information on possible savings with heat exchangers.

Electrical Load Management

Know what electric rate structure applies in your case. Read the brochure provided by your utility company explaining the available rates.

If yours is a "time-of-use" rate, you have some control over your electrical costs by scheduling loads. Devise a strategy for minimizing costs on your farm. This will involve estimating loads at various times of the day and throughout the year. Put the strategy to work, using electronic controls if they are appropriate.

LIQUID FUELS

Liquid fuels, accounting for more than half of the total farm energy used, can be substantially conserved also. Forage and grain production take the most fuel. To harvest alfalfa, a haylage system requires about 56 percent more liquid fuel per acre than does a square bale system. Following are some points to keep in mind to help trim fuel consumption in chopping forage:

Forage Harvester Operation, Adjustments, and Maintenance

Fine-tune the length of cut. Chopper power requirement increases by about one-third when theoretical length of cut is reduced by half. For corn silage, maturity of the crop is a factor in determining the best length of cut. A more mature crop should be chopped finer (down to 1/4") to maintain animal performance; and drier silage requires a shorter length of cut to pack and store well than does silage at 65% moisture or higher.

In alfalfa as well, an over-mature light crop requires a shorter theoretical length of cut than "optimum" conditions. Longer cuts can cause handling problems with blowers and augers; you should also be aware that silo capacity can vary 10 to 15 percent with length of cut. (Forage cut to 1/4" packs tighter than 3/4".) You can't get the length of cut you want if the chopper's knives are dull and its shear bar worn. Sharpen the knives and reset the shear bar daily during normal harvesting conditions. Reverse or replace the shear bar when the recommended clearances cannot be maintained at the center of the bar.

Use a recutter screen (a real energy-burner) only when poor harvesting conditions make it otherwise impossible to get the length of cut you want.

A multiple-row gathering unit saves energy by requiring less travel distance; in average conditions, a chopper with a 3-row head will use about 14% less fuel per ton of corn silage than a 2-row unit.

Manure Handling

Liquid manure storage and handling require about twice as much fuel as handling semi-solid manure. On the other hand, nutrient losses are cut to about one-third in a liquid system with soil incorporation compared to a semi-solid daily spread system.

Grain Drying

Low-temperature grain drying systems (using electricity for fans as the primary energy source) can cut energy consumption by one-third to one-half that used by liquid-fuel-fired high-speed drying equipment. This year, liquid fuels cost considerably less than electricity for the same amount of energy, so you may find that drying costs are about the same for either system at present.

Support for the printing of this article was provided by the Illinois Department of Energy and Natural Resources.

Use of Bovine Somatotropin in Dairy Production

W. R. (Reg) Gomes

Requests for information on use of bovine somatotropin (bSTH or frequently referred to as bovine growth hormone) to enhance milk production are received daily. The public should be aware of the truth on this topic. Work on bSTH and current knowledge of several related issues are summarized in a series of questions with answers.

What is bSTH? As much as 100 years ago, medical clinicians began to associate a pituitary factor with dwarfism and gigantism. By 1926 the presence was established in mammals of a hormone that was necessary for normal growth. Named "growth hormone" at that time, it was later noted that the compound reduced fat in animals, increased protein synthesis, and influenced general body metabolism in addition to effects on growth; this led to the more general term for the compound, "somatotropin."

Somatotropin is a relatively small protein that differs slightly in structure and size between species. Of even more interest to scientists and the general public, activity of somatotropin from one species is generally absent if the somatotropin is administered to another kind of animal. We know, for example, that the bovine form, bSTH, is active in cattle and has some activity in sheep, goats, rats, and mice; conversely it is without activity in guinea pigs, pigs, monkeys, and humans. For that matter no "growth hormone" from fish, chickens, rodents, or farm animals has shown activity in humans or other primates. Therefore, one must specify the hormone under study as from the human (hSTH), bovine (bSTH), pig (porcine; pSTH), sheep (ovine, oSTH), or horse (equine, eSTH). All are proteins of about 190 amino acids and a molecular weight of about 22,000.

What does bSTH do to milk production? We have suspected for fifty years that bSTH would increase milk production in dairy cows, but the scarcity and expense of the natural product (which had to be extracted from pituitary glands of slaughter house animals) prevented definitive experiments. In 1980 the availability of bSTH produced by biotechnology allowed dairy scientists at Cornell University to begin extensive studies to address this question; work at Cornell and other institutions established that injected bSTH will increase milk production per cow by 15-40 percent.

Will use of bSTH cause the loss of family farms? Unlike most recent advances in technology, bSTH is proportionally as effective for small farms as for large. No additional capital is needed and the benefits of efficiency will accrue to those dairy producers who are the best managers, be they on large or small units. If bSTH is used to produce milk more efficiently, and not to produce more milk, small farmers could stay in business without the

need to expand. If bSTH is used to overproduce further, the entire industry would suffer further.

Does bSTH cause stress and health problems for cows? The most recent data have summarized health data for cattle during the lactation of treatment and for a full year after cessation of treatment. Treated cows were as healthy by all measure for the total period as untreated cows. Animals were routinely and frequently evaluated for mastitis, reproductive efficiency, blood chemistry, cardiovascular health, and animal disease. No deleterious effects of bSTH were found. Longer term studies will be completed before FDA will approve bSTH for commercial use.

Does bSTH affect people consuming the milk from treated cows? No! The factors assuring safety are many. First of all, bSTH is inactive in humans. If people were to attempt to use the product illegally on people rather than cows to produce growth, muscle, or loss of fat (see below); the compound would not work. Additional measures of safety are derived from the following: (1 bSTH has no effect on milk composition. More milk is produced, but the amount of fat, protein, minerals, sugar, and bSTH in the milk are not changed; (2 bSTH activity is destroyed by pasteurization. After heat treatment, bSTH is inactive in cattle--it was already inactive in people; (3 bSTH and any other STH is inactive if taken orally. As a protein, it is digested before absorption and has no activity regardless of species. The FDA approves and monitors all experiments utilizing bSTH before issuing final approval of the compound. Approval will depend on overwhelming evidence of efficacy and freedom from deleterious effects on cattle. If human safety were in doubt, present experiments would not have been approved.

Are other uses of STH being studied? Yes, porcine STH administered to growing pigs produces much leaner pork--larger loin eyes (pork chops) and hams with much less fat--with less feed. bSTH is being examined for production of leaner beef. These experiments are in early stages and are being carefully monitored by FDA.

Relationship Between Energy Status of the Cow and Reproductive Efficiency

Carl L. Davis

Delayed breeding is a costly problem estimated to run between $110 and $150 per year for the average DHIA cow in Illinois. Stress imposed by high milk production is a major factor contributing to delayed breeding and a poor conception rate in dairy cows. Nutritionally, this stress most often stems from an insufficient amount of energy being consumed to meet the cow's needs and she has to draw heavily upon body stores. The critical factor is the extent to which the cow has to rely upon body stores to meet the need. This phenomenon is not peculiar to dairy cows but occurs in other species. For example the lactating sow does not cycle while nursing the piglets and the length of time from weaning to estrus in the sow appears to be closely related to the extent of weight loss during lactation. The greater the weight loss during lactation, the longer the interval between weaning and start of estrus.

To illustrate the relationship between energy status of the cow and breeding efficiency, data from a study conducted at Cornell University are cited in Table 1. Keep in mind that we are equating body weight change as an indicator of energy status. We expect good cows to undergo a moderate loss in body weight during the first 8 to 10 weeks of lactation. However, as indicated in Table 1, a severe loss in body condition is associated with a delay in appearance of first ovulation, first observable heat, and time of conception in reference to calving. Conception rate at first service for those cows which experienced severe loss of body condition was only 17 percent. Another factor which may compound the problem as indicated in this study is that a rapid and sustained loss in body weight may suppress feed intake. Note that the cows undergoing severe loss in condition ate less dry matter even though they were producing more milk.

How can we minimize the weight loss in early lactation cows so that they are in a more favorable energy status at the desired time for breeding? The first thing to do is to assure that the cow is conditioned properly during the dry period. Feed to get the cow in good flesh, but avoid getting the cow fat. Fat cows not only have a reduced gut capacity, but they tend to have a suppressed appetite. The latter is thought to be due to the high level of fatty acids in the blood resulting from the rapid mobilization of body fat stores. After calving encourage maximum dry matter intake by feeding a well balanced diet at frequent intervals. Caution should be the rule in all management decisions which might throw the cow off feed. Such things as sudden changes in ration makeup or changes in feeding location or time of feeding should be avoided. Lastly, we need to increase the energy content of the diet so the cow obtains more energy per mouth full. This necessitates incorporating a suitable fat source in the ration. By suitable

we mean one which is palatable, inert in the rumen, easily incorporated into the diet, high in net energy and economical. Dry fats, such as prilled fat, which have been specifically formulated for the dairy cow meet all the above requirements.

The results of a recent test involving 200 cows in three herds in Pennsylvania look very promising (Ferguson et al., 1987, J. Dairy Sci. Supplement, p. 207, Figure 1). Cows in each herd were randomly assigned to receive 0 or 1.0 pound of prilled fat (Energy Booster) from calving to 150 days into lactation. The results show that the cows given the fat (supplement were 2.2 times more likely to become pregnant when inseminated than those not receiving supplemental fat. The data also show that the probability of the cow conceiving at first service was 61.5 percent for the fat supplemented cows (all herds) versus 41.8 percent for the non-supplemented group.

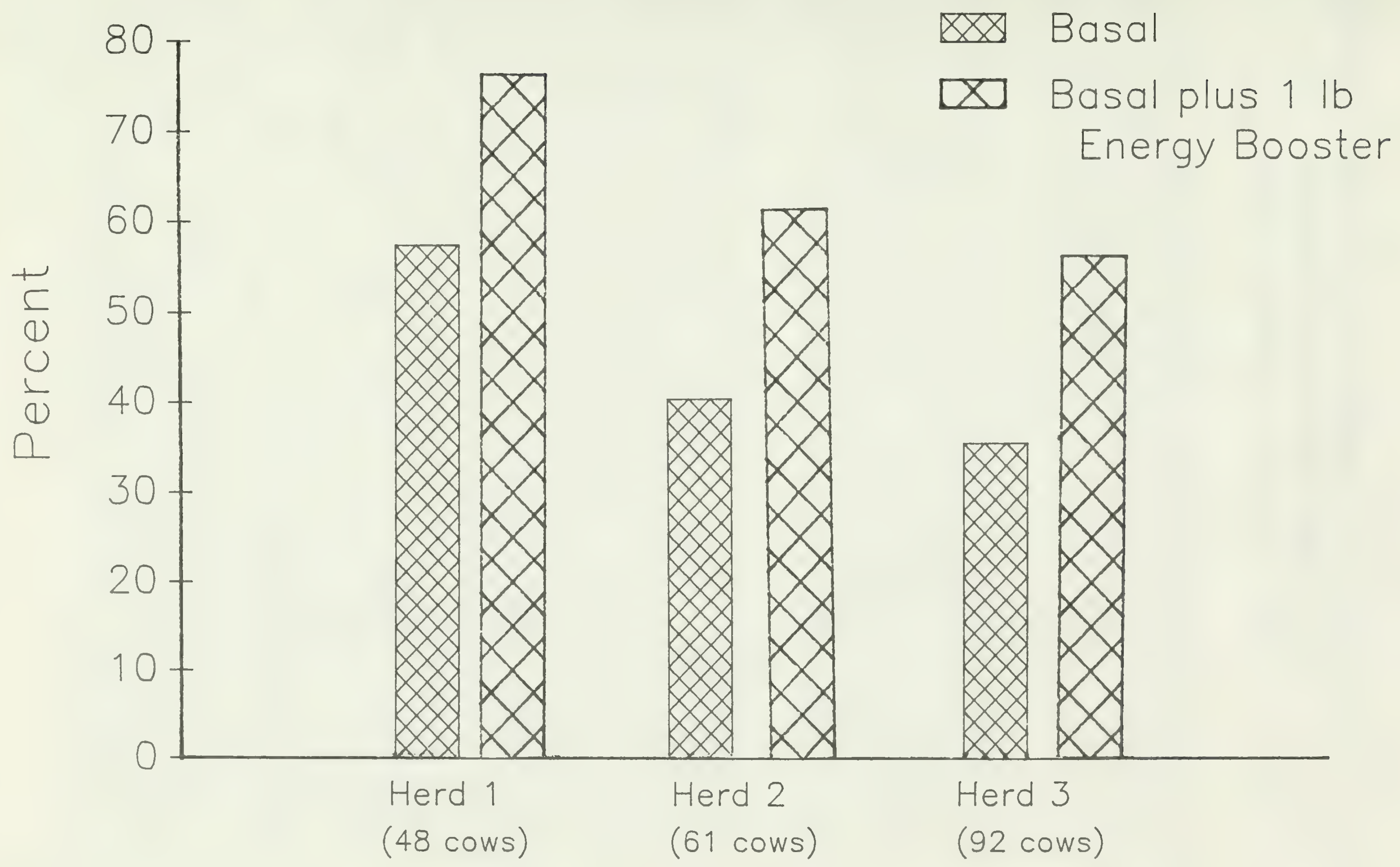
These findings certainly support the concept that there is a positive relationship between the energy status of the lactating cow and breeding efficiency. The greater the loss in body condition during the first 100 days of lactation, the greater the difficulty in getting the cow to conceive. Reducing the energy deficit of the cow by increasing the energy content of the diet, via fat supplementation, appears to give positive results in getting the cow with calf. My recommendation is to feed 1 to 1.5 pounds of a suitable fat from two weeks post calving to 150 days into lactation. Where possible, the fat should be incorporated into a complete mixed diet so that finicky eaters are less likely to be affected. Most cows will not alter their feed intake even when the fat is topdressed on the ration at a rate up to 2.0 pounds per day.

Table 1. Effect of Change in Body Condition of Holstein Cows in Early Lactation on Reproductive Performance[1]

Body Condition Change	DMI	Daily Milk Yield	Interval from calving to: First Ovulation	First Heat	Conception	Conception rate at first servic
	(lbs)	(lbs)	----------days----------			(%)
Minor loss	44.2	63.1	27	48	74	65
Moderate loss	43.6	66.0	31	41	90	53
Severe loss	40.9	67.1	42	62	116	17

From Smith et al., 1986. J. Da. Sci. (Supplement) p. 245.
Change in body condition score over first 5 wks of lactation.
Means over first 14 wks of lactation.

Figure 1. Effect of Fat Feeding on Breeding Efficiency: Probability of Cow Conceiving at First Service.



Effects of Various Concentrate Delivery Methods for Cows Housed in Groups

Mark G. Cameron and Sidney L. Spahr

During the last 20 years, major changes have taken place in the development of feeding systems for dairy cows. As the trend towards larger herds and more parlors continues, dairy producers are striving to minimize labor costs and maximizė their economic returns by taking advantage of automated feeding systems. With the grouping of dairy herds, it is not always possible to get enough concentrate into the high producing cow to hold peak lactation yields while in the parlor. Thus, attempts were made to feed concentrate in the outside feed bunk. However, concentrate intake for individual cows at the feed bunk is poorly controlled, a situation which led to the development of computer-controlled feed dispensers. The feed dispenser can allot concentrate to selected cows, which receive a preferential plane of nutrition although housed in groups and fed forage or a total mixed ration (TMR) on a communal basis.

One hundred thirty-nine primiparous (first-calf heifers) and multiparious (second lactation plus) cows were randomly assigned to 3 treatments (trts) based on milk yield and lactation number, between weeks 3 and 36 of lactation in a 32-week trial. The objective was to compare the effects of various feeding systems on individual cow production responses when coupled with individual-cow ration balancing for cows housed in groups. Treatments varied by method of concentrate delivery and were: 1) 100 percent concentrate fed via dual-feed dispenser (Surge) with forage fed in the bunk; 2) 50 percent concentrate fed via single-feed dispenser (DeLaval), 50 percent mixed with the forage and fed in the bunk; and 3) all concentrate and forage fed via the bunk as a TMR. Forage was 50 percent corn silage and 50 percent alfalfa haylage on a dry matter basis. Concentrate ingredients were ground shelled corn (energy source) and soybean meal (protein source) with a mineral/vitamin mix added to meet National Research Council requirements. Treatment 1 received their concentrates via a dual-feed dispenser while the other trts had a blended grain mix of the above ingredients.

Rations were balanced biweekly for all trts with the Illini Ration Balancer. The ration balancer gives a recommended grain and forage allocation to meet each individual cow's nutrient requirements based on that individual cow's measurements for daily milk yield, milk fat percent, and body weight.

The results indicated that there were no significant differences among trts for milk yield. There was a trend for increased milk yield for cows using the grain transponders in early lactation (Figure 1). Daily milk production appeared to peak higher and remained higher until week 20 of lactation for cows fed all or partial amounts of the concentrate via a feed dispenser as compared to cows fed the TMR. Treatment 1 produced 2.2 to 4.4 pounds more milk per day than did trt 2 until week 11 of lactation.

Milk fat percentages were not different among trts. Milk fat percentages were variable from early to late lactation and tended to level off at 3.4 to 3.6 percent for most of the trial. An absence of milk fat percentages below 3.4 percent indicated that the ration balancer was effective in preventing depressed milk fat percentage.

Highly significant differences in protein percentages occurred for the feed dispenser trts as compared to the TMR trt. A possible explanation for increased daily protein yield is that protein synthesis was more efficient when cows had continuous access to their concentrate throughout the day. Smaller and more frequent consumption of concentrates should result in a more constant energy intake, hence a better synthesis of protein and this could result in an increased protein supply to the mammary gland.

Individual dispensing of at least half the concentrate resulted in less weight loss during early lactation, earlier attainment of positive weight change, and greater weight gains through week 36 of lactation. The magnitude ot these effects was greater with the dual-feed dispenser as compared to the single-feed dispenser.

In early lactation (Figure 2), trt 1 and 2 had increased daily income-over-grain-cost ranging from $.20 to $.70 per day than cows on trt 3. The benefit was most pronounced for cows fed concentrate via a dual-feed dispenser as compared to concentrate fed via the single-feed dispenser or in the TMR. Therefore, ration balancing for individual cows housed in groups is benefical when coupled with the feed dispensers for increased income-over-grain-cost.

In conclusion, there appears to be an advantage in milk yield, protein percentage, change in body weight, and in income-over-grain-cost for cows receiving all or partial amounts of concentrate via a feed dispenser as compared to concentrate fed via the TMR. This advantage in feeding concentrates via a feed dispenser was most noticeable in the early stages of lactation (weeks 3 through 18) and should increase economic returns. An individual-cow ration balancing program is economical and efficient for lactating cows housed in groups fed under a communal basis.

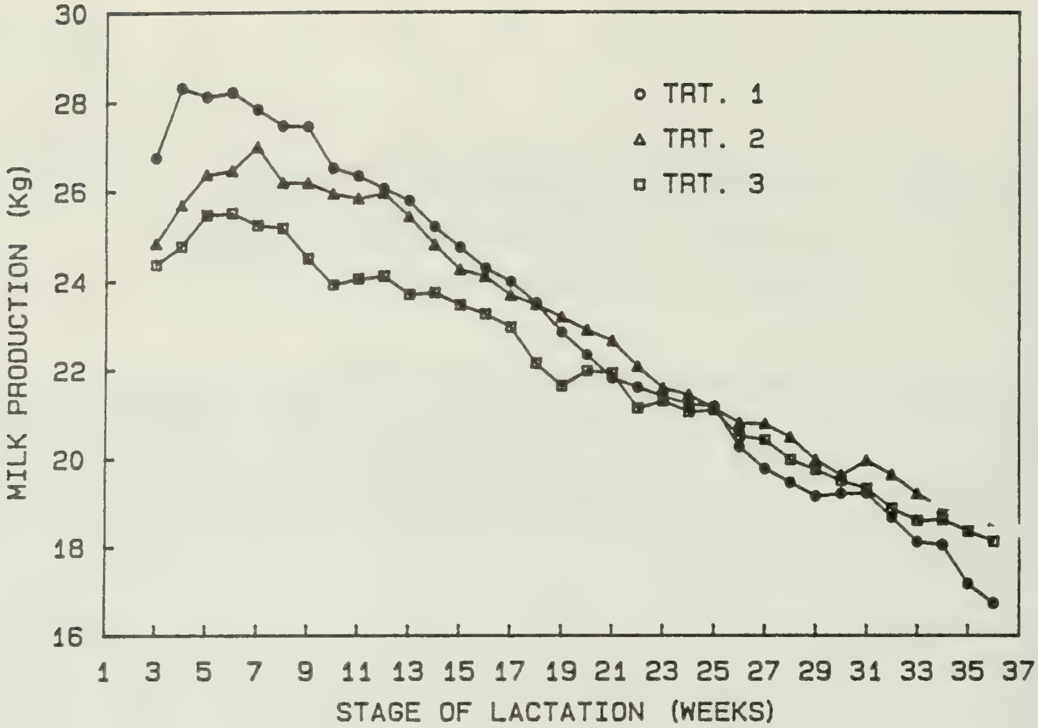


Figure 1. Daily milk production by treatment for weeks 3 through 36.

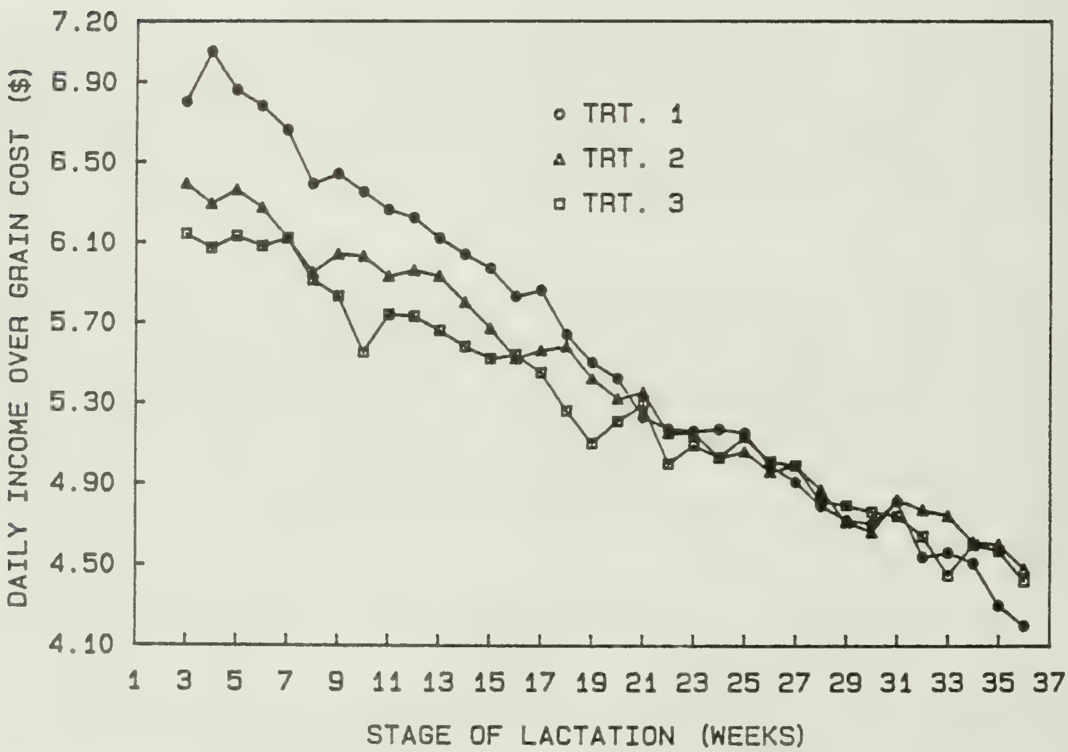


Figure 2. Daily income-over-grain-cost by treatment for weeks 3 through 36.

Supplemental Niacin or Niacinamide for Lactating Dairy Cows

Edwin H. Jaster

During early lactation the combined effects of slowly increasing dry matter intake, high milk production, and decreasing body weight impose a severe metabolic stress on the high-producing dairy cow. Approximately one-half of the cows in high-producing herds experience borderline ketosis during early lactation. Adding niacin (vitamin B_3) to dairy cow rations has improved milk production and milk persistency and has reduced incidence of ketosis. It is recommended that feeding niacin from two weeks prior to calving through the first 100 days of lactation, at 6-12 grams per head per day will be the most effective. High producing cows under stress of making high milk production levels have demonstrated the best responses to niacin supplementation (1983 Illinois Dairy Report, page 36).

Most research involving vitamin B_3 and dairy cattle has been done with niacin. However, recently research reports from Europe have compared niacin and its amide derivative, niacinamide. Niacinamide was shown to increase milk production in a comparable manner to niacin. The objectives of this study were to examine the effect of feeding supplemental niacin or niacinamide (6 g/day) on milk production and metabolite changes associated with early lactation in dairy cows. During the experiment 30 cows were assigned to three groups. The treatment groups received 6 g niacin or 6 g niacinamide per head per day beginning 2 week prior to calving to 12 week after calving. The control group received no treatment. Cows receiving niacinamide produced more milk (week 8 through 12) than controls (Figure 1). There were no changes in milk composition, dry matter intake, or body weight change. Concentrations of beta-hydroxybutyrate (ketone body) in blood serum (week 4) were lower for cows receiving niacin or niacinamide (Figure 2). Serum glucose concentration (week 4-6; Figure 3) was higher and free fatty acids (week 4; Figure 4) were lower for cows receiving niacinamide. Beneficial effect of niacin or niacinamide appears related directly to its control of ketosis.

Figure 1. Milk production for dairy cows supplemented with 6 g niacin or niacinamide.

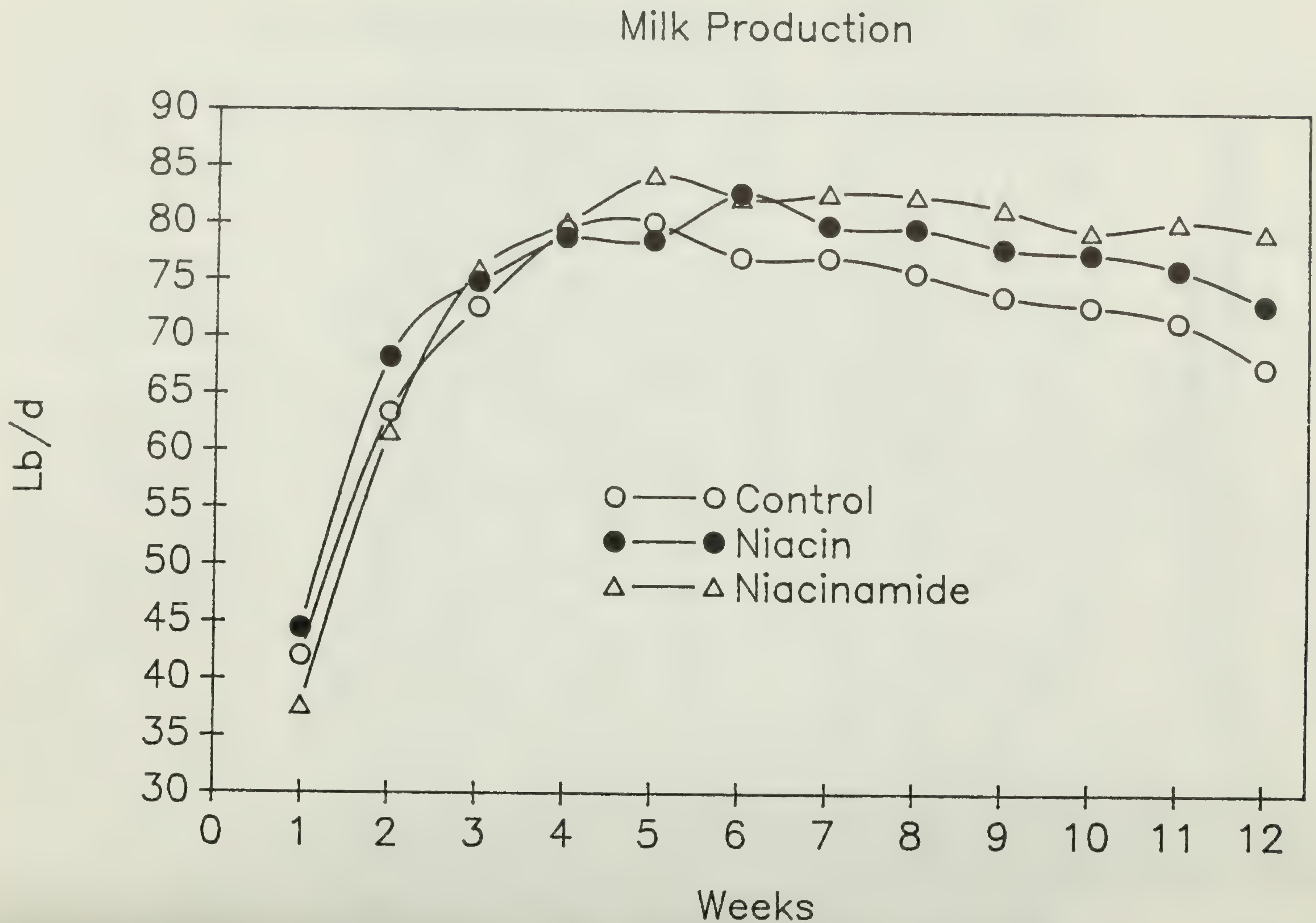


Figure 2. Concentrations of β-hydroxybutyrate with 6 g niacin or niacinamide.

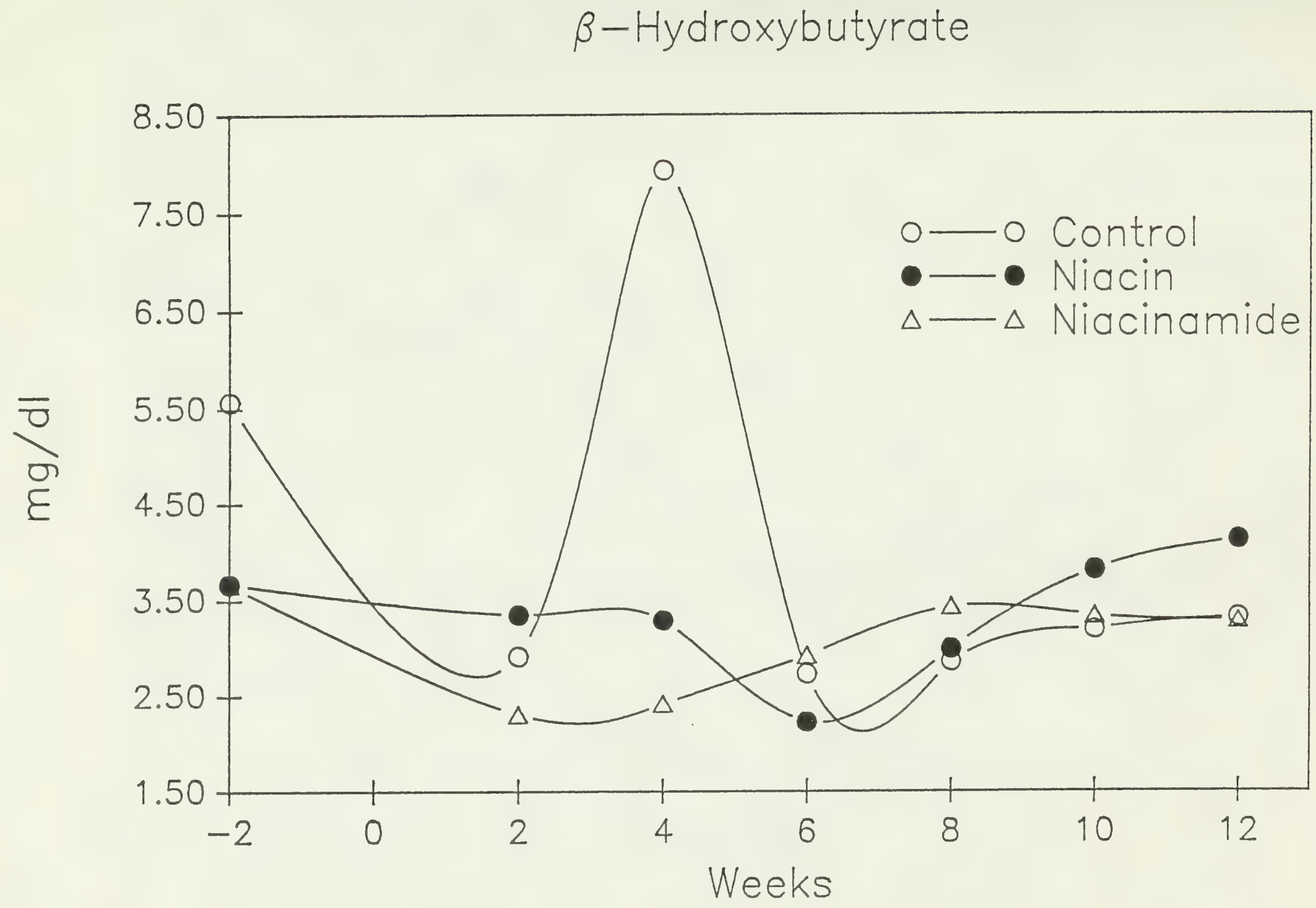


Figure 3. Concentrations of glucose with 6 g niacin or niacinamide.

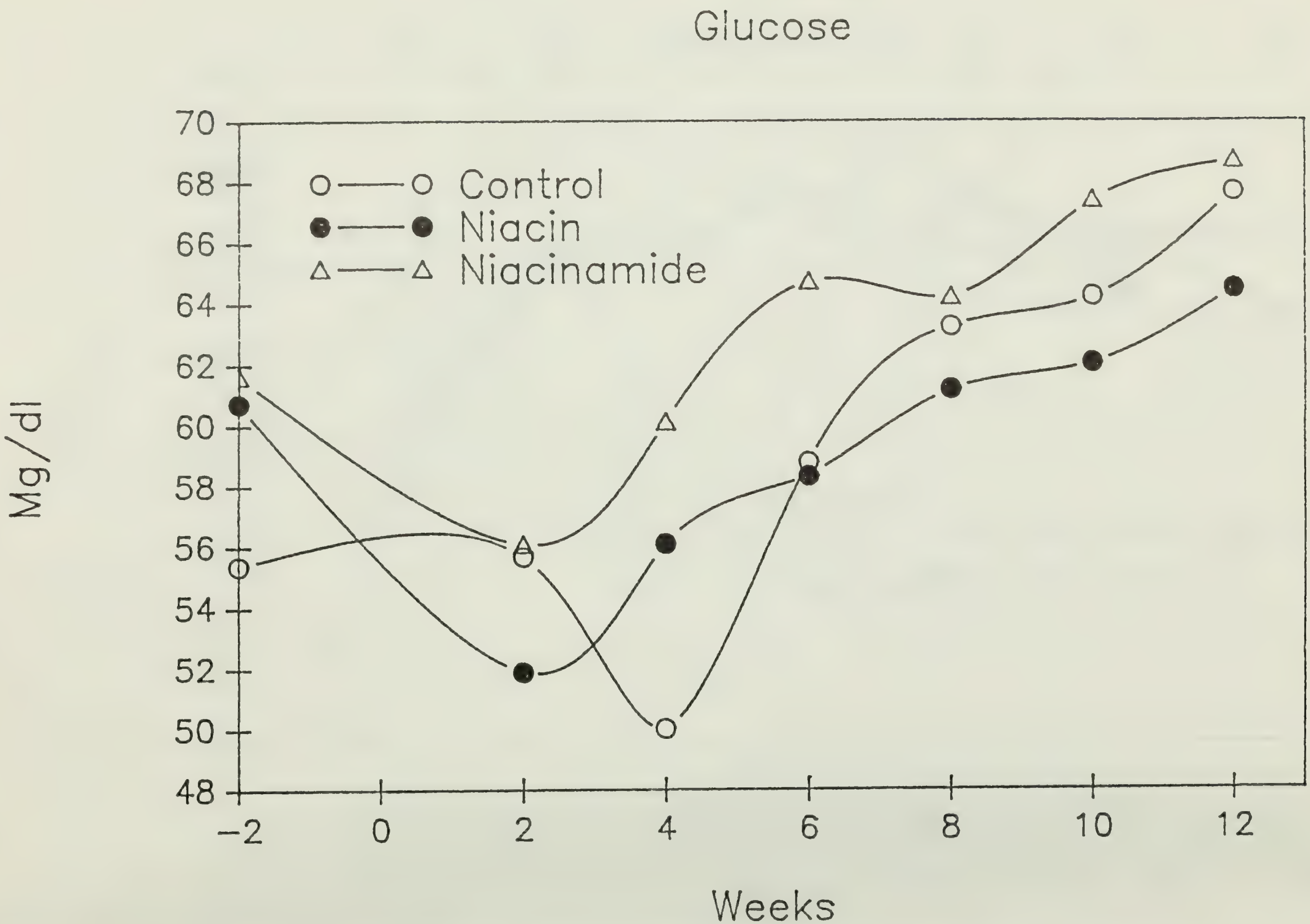
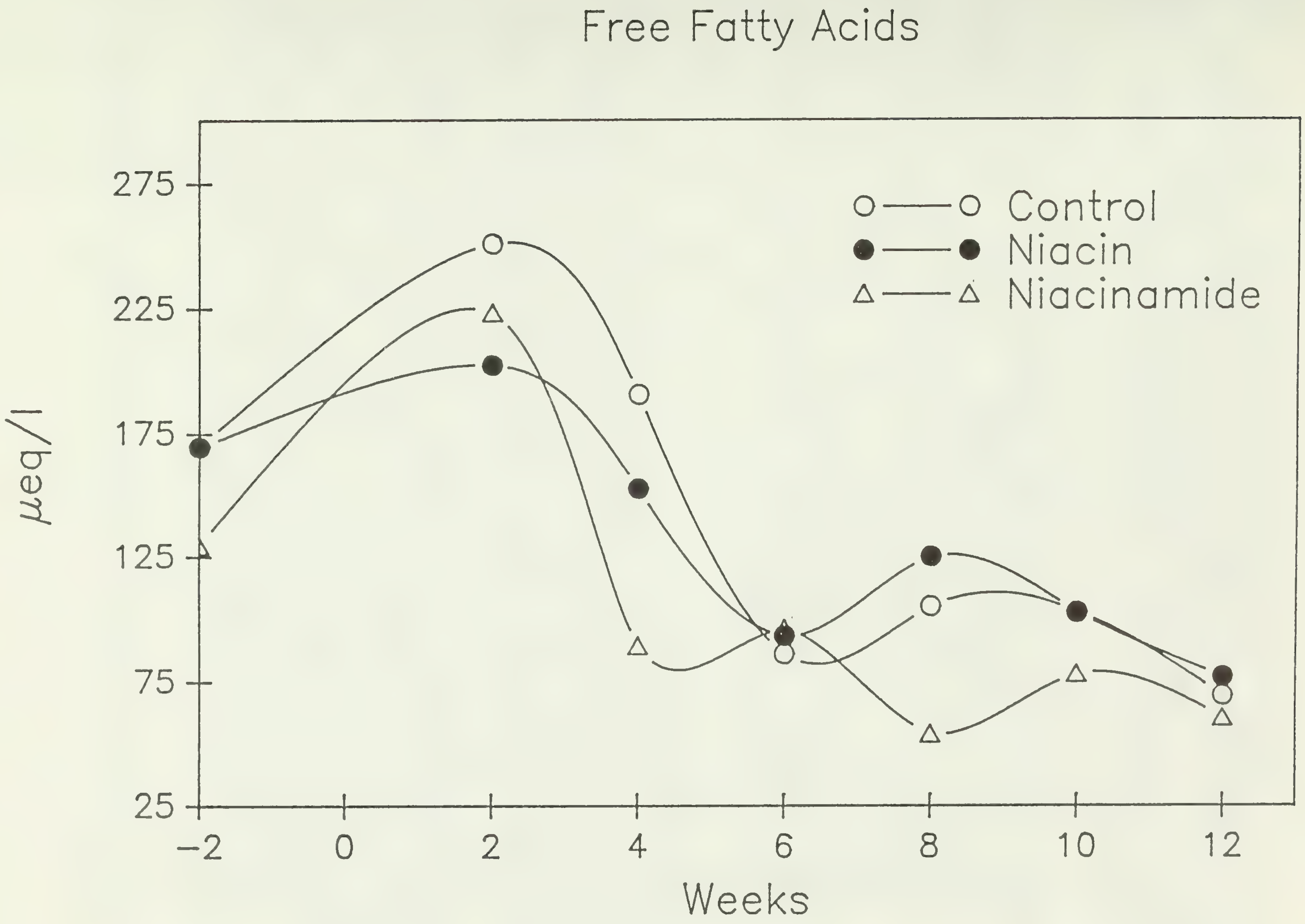


Figure 4. Concentrations of free fatty acids with 6 g niacin or niacinamide.



Effects of Source of Energy and Protein on Nutrient Passage to the Small Intestine and Performance of Dairy Cows

Robert D. McCarthy, Jr., Tim H. Klusmeyer, Jimmy H. Clark, and Dale R. Nelson

The requirement for nutrients to support high milk production during early lactation is great. Cows in early lactation often suffer from a shortage of energy and protein because maximal dry matter intake does not occur until after peak milk production. Therefore, cows mobilize energy and protein from body tissue to support milk production. To achieve peak milk production, the quantity of nutrients supplied to the cow must be maximized. Two approachs for increasing nutrient supply to the cow are to increase the quantity and improve the ratio of end products of ruminal fermentation and to supplement nutrients to the diet that will escape ruminal fermentation and pass to the small intestine. The objective of this trial was to investigate the effects of feeding fish meal or soybean meal and corn or barley on ruminal fermentation, nutrient passage to the small intestine, apparent total tract nutrient dig estibility, milk production, and milk composition.

MATERIALS AND METHODS

Four Holstein cows fitted with ruminal and duodenal cannulae and averaging 51 days postpartum were used in a 4 x 4 Latin square. Each period in the square was 16 days with 13 days for adjustment and 3 days for data collection. Diets were in a 2 x 2 factorial arrangement and consisted of corn and fish meal, corn and soybean meal, barley and fish meal, and barley and soybean meal and diets were supplemented with minerals and vitamins to meet requirements of the cows. Diets were fed twice daily, as a total mixed ration, that consisted of 45% forage (corn silage and alfalfa grass haylage) and 55% concentrate. Diets contained about 69% dry matter and 14.5 to 15% crude protein. Starch was slightly higher and acid detergent fiber slightly lower for the corn based diets.

Chromium oxide was used as a digesta flow marker and purines were used to estimate microbial N passage to the small intestine. Ruminal and duodenal samples were collected every 3 hours during the last 3 days of each period so that each hour in a 24 hour period was represented. Ruminal bacteria were collected and isolated 6 times during each period. Feces were collected twice daily during the last 5 days of each period. Milk yield and milk composition were measured during the last 7 days of each period.

Data were analyzed by orthogonal comparisons for fish meal vs. soybean meal, corn vs. barley, and the interaction between sources of protein and energy.

RESULTS

Cows fed corn consumed more organic matter than cows fed barley (Table 1). However, a larger quantity and percentage of organic matter was apparently and truly digested in the rumen when barley was fed. Total tract digestibility of organic matter was not different between corn and barley diets, therefore, more organic matter was digested postruminally when corn was fed. Source of protein did not affect organic matter intake, apparent or true ruminal digestibility, or total tract digestibility.

Cows fed corn consumed more starch than cows fed barley because of their greater dry matter intake and because of the greater starch content of the corn diets (Table 1). However, more starch was fermented in the rumen when barley was fed compared to corn. In contrast, a larger quantity and percentage of starch was digested postruminally when corn was fed compared to barley. Total tract digestibility of starch was greater for barley diets than for corn diets. Source of protein did not affect either the site or extent of starch digestibility.

The rapid and extensive degradation of starch for all diets, and especially for barley diets, resulted in high concentrations of volatile fatty acids in rumen fluid (Table 2). This depressed ruminal fluid pH to values that averaged less than 6 for all treatments (Table 2). The molar concentration of acetate was higher and the molar concentration of propionate was lower when corn was fed compared to barley. This resulted in a lower acetate to propionate ratio in ruminal fluid when barley was fed. Source of protein did not influence the concentrations of volatile fatty acids as much as the source of energy, but significant interactions were observed. Concentrations of ammonia-N in ruminal fluid averaged less than 4 mg/dl for each treatment (Table 2). Concentrations of ammonia-N in rumen fluid were greater when corn replaced barley and when soybean meal replaced fish meal in the diets. However, increasing the ammonia concentration by replacing fish meal with soybean meal did not alter either apparent or true digestibility of organic matter in the rumen (Table 1).

Feeding corn increased N intake because of the larger quantity of feed consumed (Table 3). Feeding corn also increased nonammonia N (NAN) and nonammonia nonmicrobial nitrogen (NANMN) passage to the small intestine compared to feeding barley. However, feeding barley increased microbial nitrogen passage compared to feeding corn probably because a larger amount of organic matter was fermented in the rumen when barley was fed which increased energy for growth of the microbes. Source of supplemental protein did not affect nitrogen intake or the amount of NAN and NANMN that passed to the small intestine. Feeding SBM increased the passage of microbial nitrogen to the small intestine compared to feeding fish meal.

Feeding corn resulted in NANMN making up a larger fraction and microbial N a smaller fraction of the NAN compared to feeding barley (Table 3). This was probably due to the increased degradation of organic matter in the rumen which increased available energy for microbial protein synthesis. Likewise, feeding fish meal increased the ratio of NANMN to microbial N that passed to the small intestine compared to SBM. Reasons for this altered ratio when different supplemental proteins were fed may be an increase in available energy, ammonia, amino acids or peptides derived from more complete ruminal degradation of SBM than fish meal. It appears that the ratio of dietary N to microbial N can be altered more easily and consistently than the total quantity of NAN that passes to the small intestine. Microbial N that passed to the small intestine ranged from 51 to 58 g/kg of organic matter apparently digested and from 31 to 35 g/kg of organic matter truly digested in the rumen and was not different among sources of energy or protein.

The passage of threonine, methionine, isoleucine, leucine, phenylalanine, and histidine to the small intestine was greater when corn was fed compared to barley (Table 4). Three factors may have contributed to the greater passage of these amino acids to the small intestine. First there was a greater intake of these amino acids when corn was fed, second, more of the protein in barley than in corn was probably degraded in the rumen, and third, nucleic acids made up a larger portion of the NAN that passed to the small intestine when barley was fed compared to corn. Although the intake of some of these amino acids was altered by source of supplemental protein, the quantity of individual amino acids that passed to the small intestine was not different probably because supplemental protein supplied only 15 to 30% of the total protein in these diets and a portion of this was degraded in the rumen. Furthermore, almost one-half of the NAN that passed to the duodenum was microbial N which had an equalizing effect on the passage of individual amino acids to the small intestine.

Feeding corn increased the yields of milk, milk protein, and solids-not-fat probably because of the greater passage of starch and amino acids to the small intestine (Table 5). Yields of milk fat and 4% FCM were not altered by source of energy. Source of supplemental protein did not affect yields of milk, protein, solids-not-fat, fat, or 4% FCM.

SUMMARY

Barley based diets supplied more energy for microbial growth. Corn-based diets increased organic matter, starch and amino acid passage to the small intestine. Source of supplemental protein did not affect passage of NAN to the small intestine. Microbial N made up a larger fraction of total N that passed to the small intestine than did protein supplements and this had an equalizing effect on passage of individual amino acids. Feeding corn increased production of milk and milk protein probably because of increased passage of organic matter, starch and amino acids to the small intestine

Table 1. Least square means for intake and digestibility of organic matter and starch in various segments of the gastrointestinal tract

Item	Treatments: Corn, Fish meal	Corn, Soybean meal	Barley, Fish meal	Barley, Soybean meal	SEM
Organic matter					
Intake, kg/d	21.8	22.6	19.0	19.5	0.6
Apparently digested in rumen, kg/d	5.4	5.2	6.3	6.4	0.6
Truly digested in rumen, kg/d	8.5	8.5	9.8	10.2	0.6
Apparent total tract digestibility, %	66.5	67.3	67.2	66.1	1.2
Starch					
Intake, kg/d	10.3	11.0	8.2	8.6	0.3
Apparently digested in rumen, kg/d	5.3	5.1	6.3	6.7	0.2
Apparent total tract digestibility, %	92.9	93.5	96.7	96.8	0.7

Table 2. Least square means for ruminal pH, volatile fatty acids and ammonia-nitrogen

Item	Treatments: Corn, Fish meal	Corn, Soybean meal	Barley, Fish meal	Barley, Soybean meal	SEM
VFA, mM[1]	104.20	119.48	122.66	118.56	1.28
pH	5.96	5.72	5.62	5.73	.04
Acetate, molar %[1]	61.61	58.42	56.37	58.29	.15
Propionate, molar %[1]	23.95	28.75	32.98	28.97	.22
Acetate/propionate ratio[1]	2.64	2.14	1.74	2.12	.03
Butyrate, molar %	11.54	10.20	8.24	10.17	.12
Ammonia N, mg/dl	2.86	3.54	1.39	2.83	.20

[1]Significant energy by protein interaction.

Table 3. Least square means for intake of nitrogen and passage and digestion of nitrogenous compounds in different segments of the gastrointestinal tract.

Item	Treatments: Corn, Fish meal	Corn, Soybean meal	Barley, Fish meal	Barley, Soybean meal	SEM
Intake, g/d	544	567	483	504	22
Flow to the duodenum					
NAN, g/d[1]	632	666	589	599	28
NANMN, g/d[2]	373	372	307	289	18
Microbial N, g/d	259	294	282	310	11
Microbial N					
g/kg OMAD[3]	51.3	58.6	52.8	52.6	6.8
g/kg OMTD[4]	31.2	35.2	30.9	31.2	2.5

[1]Nonammonia nitrogen.
[2]Nonammonia nonmicrobial nitrogen.
[3]Organic matter apparently digested in the rumen.
[4]Organic matter truly digested in the rumen.

Table 4. Least square means for passage of amino acids to the duodenum.

Amino Acid	Treatments: Corn, Fish meal	Corn, Soybean meal	Barley, Fish meal	Barley, Soybean meal	SEM
	(g/day)				
Threonine	164	167	155	151	6
Valine	200	226	200	200	10
Methionine	83	81	71	68	5
Isoleucine	178	192	162	167	7
Leucine	348	388	284	279	12
Phenylalanine	173	190	161	162	6
Histidine	74	80	69	66	3
Lysine	246	234	228	229	10
Arginine	166	168	162	156	8

Table 5. Least square means for milk and milk component yields

Item	Treatments: Corn, Fish meal	Corn, Soybean meal	Barley, Fish meal	Barley, Soybean meal	SEM
Milk, (lb/d)	79.0	77.4	71.3	71.7	1.3
Milk CP, (lb/d)	2.53	2.43	2.22	2.27	.04
Milk SNF, (lb/d)	6.95	6.84	6.25	6.31	.13
Milk fat, (lb/d)	2.11	2.02	2.02	2.16	.11
4% FCM, (lb/d)	63.4	61.4	58.7	61.2	1.54

Fermentation in the Cecum and Large Intestine of Steers

Joanne Siciliano-Jones and Michael R. Murphy

Dairy cattle consume large amounts of feed in early lactation. As feed intake increases, the proportion of material fermented by microbes in the reticulorumen and digested in the animal's abomasum and small intestine is thought to decrease. This means that microbial fermentation of material reaching the cecum and large intestine probably plays a more important role in nutrition of these animals, particularly those being fed high grain diets. Other than general recognition of the possible importance of fermentation in the cecum and large intestine, its contribution to total tract digestion and the energy status of dairy cattle has not been determined at high levels of intake. This study was designed to provide quantitative information about digestion in various segments of the gastrointestinal tract for several diets.

Four 600 pound Holstein steers were fitted with ruminal, duodenal (first segment of the small intestine), and ileal (terminal segment of the small intestine) cannulas. They were assigned to a 4x4 Latin square with 18 day periods. Treatments consisted of two forage types (alfalfa hay in long form or ground and pelleted) fed at two forage to concentrate ratios (20:80 or 80:20, as fed). Sodium bicarbonate was added to the high grain diets at 1.5 percent of total dry matter. The animals were fed ad libitum and feed was offered three times per day. Ruminal, small intestinal, and cecal and large intestinal digestibilities of organic matter, crude protein, neutral detergent fiber (NDF), acid detergent fiber (ADF), and starch were determined.

Results of the experiment are shown in Table 1. Maximum dry matter consumed by the multiply-cannulated steers was 2.7 percent of body weight per day. This is about 70 percent of that of dairy cows in early lactation. Nutrient digestion in the cecum and large intestine was greatest for the diet most similar to that normally fed to cows in this phase of lactation (80 percent grain, 20 percent hay). For this diet fiber digestion (NDF and ADF) in the cecum and large intestine accounted for 15 percent of that which occurred in the total tract. About 9 percent of the total apparent organic matter digestion occurred in this segment. True organic matter digestion in the cecum and large intestine was actually greater; therefore, it appears that fermentation in this segment of the tract makes an important contribution to overall digestion under these conditions. For lactating cows eating substantially greater quantities of feed, the contribution of the cecum and large intestine may well increase.

Table 1. Intake and Digestibility of Nutrients[a]

Measure	80% Grain: 20% Hay	80% Grain: 20% Pellets	20% Grain: 80% Hay	20% Grain: 80% Pellets
DM intake, % of body wt.	2.7	2.1	2.3	2.0
OM digested, lb	11.9	9.4	9.5	6.6
% of consumed	80.6	77.5	77.3	62.9
% of total in				
Rumen	52.8	62.4	73.1	62.3
SI	38.4	34.8	26.0	41.5
CLI	8.8	2.8	.9	-3.8
CP digested, lb	2.0	1.6	2.0	1.3
% of consumed	77.3	73.7	79.4	64.5
% of total in				
Rumen	21.0	21.8	50.4	4.1
SI	75.8	79.5	49.3	102.1
CLI	3.2	-1.3	.3	-6.2
NDF digested, lb	2.9	2.2	3.8	2.0
% of consumed	65.4	58.4	66.7	40.4
% of total in				
Rumen	70.8	75.8	84.6	81.1
SI	13.8	17.7	10.5	17.7
CLI	15.4	6.5	4.9	1.2
ADF digested, lb	1.1	.6	2.4	1.1
% of consumed	56.1	39.5	64.0	32.5
% of total in				
Rumen	59.4	48.1	78.9	71.8
SI	25.7	45.4	16.0	26.8
CLI	14.9	6.5	5.1	1.4
ST digested, lb	7.1	5.8	2.2	1.7
% of consumed	94.2	95.6	98.7	99.3
% of total in				
Rumen	51.4	66.4	65.7	65.4
SI	42.7	30.2	33.5	34.0
CLI	5.9	3.4	.8	.6

[a] DM = dry matter, OM = organic matter, SI = small intestine, CLI = cecum and large intestine, CP = crude protein, NDF = neutral detergent fiber, ADF = acid detergent fiber, and ST = starch.

DUMPS Carrier Bull Released into Active Service: Questions and Answers

Roger D. Shanks and James L. Robinson

Landmark Genetics began marketing semen from Happy-Herd Beautician in August 1987. This Holstein bull had a TPI (total production index) of 878 and was 4th among bulls with 50 percent or greater repeatabilities on the July 1987 USDA Sire Summary List. Landmark Genetics has also disclosed that Happy-Herd Beautician is a carrier for the genetic condition known as DUMPS. This disclosure has raised a number of questions. Since we discovered DUMPS here at the University of Illinois and have done almost all the research on the condition, we feel an obligation to answer these questions.

What is DUMPS? DUMPS is an inherited condition that occurs in Holstein cattle. DUMPS stands for deficiency of uridine monophosphate synthase, an enzyme found in all body cells.

How is DUMPS transmitted? It is transmitted as an autosomal recessive trait, like pink tooth and mulefoot. A carrier-normal mating results in one-half normal offspring and one-half carriers. If two carriers mate, it is expected that one-quarter of their offspring will be normals, one-half will be carriers, and one-quarter will be homozygous recessives.

What is bad about DUMPS? Embryos homozygous for DUMPS die early in gestation and do not survive to birth. We have conducted carrier-carrier matings at the University of Illinois dairy farm over the past four years. Our expectations were for one-quarter normal offspring, one-half carriers, and one-quarter homozygous recessives. We have had 6 normal calves born, 11 carrier calves born, and 8 instances of embryonic death. In the latter cases, cows were confirmed pregnant between 32 and 48 days post-conception, but were subsequently found to be open. These embryonic deaths correspond quantitatively to the homozygous recessive genotype. The embryos appear to be lost or resorbed during the first two months of gestation, leading to more services per calving and longer than normal calving intervals for these carrier-carrier matings.

Why do homozygous recessive embryos die? They die because they lack the enzyme uridine monophosphate synthase. This enzyme manufactures certain constituents of DNA and RNA, and is essential for growth and development. Without this enzyme, embryonic growth ceases, apparently within the first two months of gestation.

How common are DUMPS carriers? We estimate that 1-2 percent of U.S. Holsteins are carriers for this condition. In a study of 880 Holstein cows in Illinois in 1982, the minimal incidence was 1.7 percent. Among 287 Holstein bulls from A.I. companies around the country and active in 1985, the incidence was 1.4 percent.

Are other breeds affected? DUMPS has been detected only in Holstein cattle, although studies of other breeds have been limited. DUMPS carriers were not identified among leading bulls of the American Jersey breed, a 39-cow herd of U.S. Black Angus or 53 bulls representative of the MRIJ breed (Dutch Red and White).

How long has DUMPS been around? We suspect it has been around for 40 years, since before the widespread use of artificial insemination.

Do animals that are carriers for DUMPS look any different from normal? No, they do not show any outward appearance of being carriers. They also appear to grow and develop normally.

Do cows that are carriers for DUMPS have reproductive problems? When mated to normal bulls, carrier cows in second or later lactations had calving intervals 37 days longer than their normal contemporaries. First lactation carrier cows had calving intervals 23 days shorter than normal contemporaries. Further research will be needed to clarify the role of DUMPS on reproductive performance of DUMPS carriers. DUMPS is clearly not responsible for all reproductive problems. However, when mated to a carrier bull, carrier cows are expected to require more services per calving and to have longer calving intervals.

Do cows that are carriers for DUMPS produce less milk? Probably not; the evidence suggests that milk production may actually be higher in second and later lactations, perhaps because they also have longer calving intervals. Further research is needed in this area as well. The milk from carrier animals has a higher than normal level of orotic acid. But, biochemical analysis is needed to detect this difference.

How can DUMPS carriers be identified? A blood test will identify DUMPS carriers; they have half the normal activity of the enzyme uridine monophosphate synthase, as measured in their red blood cells. Our laboratory can perform this test; you may contact us for information on the procedure for sending samples. A fee of $25 will be charged for each sample analyzed.

Should all cows be tested for DUMPS? No, the frequency is quite low and all known cases are descendants of a single sire line. If you plan to mate a cow with a suspect pedigree to a carrier bull, you should consider having her tested. Progeny of carrier bulls should be tested to exonerate normal offspring.

Which sire line is associated with DUMPS? All carrier bulls with known pedigrees are direct descendants of Skokie Sensation Ned. Female carriers are also related to this sire line. The likelihood of an animal being a carrier diminishes as the relation to Ned becomes more distant.

Are any other carrier bulls active in AI? To the best of our knowledge, Beautician was the only carrier among the top 400 TPI bulls active in Fall 1987. Bulls entering young-sire progeny-testing schemes are being screened for DUMPS and AI organizations are refraining from progeny-testing known carriers.

What happens if a carrier bull is mated to my non-carrier cows? Half of the offspring will be carriers and half will be normal. A blood test would be necessary to distinguish the carriers from the normals.

What is the attitude of the Holstein Association toward DUMPS? The Holstein Association has been concerned about this condition since we discovered it in 1980. They have supported our research to better understand the condition. The Holstein Association is moving to declare DUMPS an enzyme deficiency with corresponding identification of carriers and development of testing procedures to monitor the population.

What do you recommend about DUMPS? We recommend that carrier-carrier matings be avoided, although only a quarter of such matings will be affected directly in a deleterious manner. We support declaring DUMPS an undesirable recessive and recommend that all suspect Holsteins be appropriately labelled as carriers or non-carriers. We feel that DUMPS carrier bulls should not enter milk-production progeny-testing schemes. We urge producers to weigh carefully the benefits and costs of using a carrier bull on their normal cows. The benefits, in the case of an excellent bull like Beautician, include the high-producing heifers and normal sons that are likely to result. The major cost is the spreading of a harmful gene among one's herd.

Storage of Embryos in the Refrigerator at 4°C

Charles N. Graves and Colleen M. Wagner

For successful embryo transfer the donor animal from which the embryo is obtained and the recipient animal into which the embryo will be transferred must be closely synchronized in the stage of their estrous cycles. This means that if the recipient is more than a day ahead of or behind the donor, the uterus of the recipient into which the embryo will be placed will not support the subsequent development of the embryo and the embryo will die. This requirement of a close synchrony between the donor (or stage of development of the embryo) and the recipient often creates a problem when more embryos are flushed from the donor cow than there are closely synchronized recipients available. These excess embryos may be discarded, frozen and stored at -196°C until used (if a freezer and storage tank of liquid nitrogen is available), or a search quickly conducted to find additional recipients at the correct stage of the estrous cycle. Each of these alternatives is expensive. In the first place few dairy producers can afford to discard genetically superior embryos, especially when time and money have been spent in obtaining them. If the choice is made to freeze the embryos for later transfer, that too can be expensive since these freezers generally cost from $12,000-$19,000 and anyone who has one is usually justified in charging for its use. In addition, viability of up to 50 percent of the embryos is lost due to the freezing and thawing damage.

One alternative would be to store the embryos at 4°C, (refrigerator temperature) for short periods of time until more recipients might be obtained. Storage of these embryos for 10 days would allow for: 1) the injection of prostaglandin ($PGF_{2\alpha}$) into additional potential recipients; 2) time for these injected cows or heifers to come into estrus (2-3 days); and 3) reach the correct day postestrus (the same day postestrus as the stored embryos were flushed).

Mouse embryos were used for these initial studies because they are very similar to bovine embryos and also are available in larger numbers. Criteria for success were in the first series of experiments the ability of the embryo following storage to develop in culture *in vitro* to the expanded blastocyst stage, and in the second series of experiments their development in culture *in vitro* as well as the birth of normal young following transfer to recipients.

In the first series of experiments embryos were stored in a phosphate buffered saline medium containing 3 mg bovine serum albumen per ml for up to 8 days at $4^{o}C$. Following storage the embryos were transferred to a Krebs-Ringer bicarbonate medium and cultured to allow further development. When assayed at the end of culture, of the 350 embryos stored for 0, 1, 2, 3, 4, 5, 7 and 8 days; 83, 73, 64, 76, 54, 46, 16 and 0 percent, respectively, developed into expanded blastocysts. These results showed that mammalian embryos can be maintained at $4^{o}C$ for several days and then subsequently develop in culture, but gives little evidence to indicate whether they will develop into live young following the storage. Therefore, in a subsequent experiment the 8-cell embryos were stored for various intervals, then cultured for a short time to determine if the embryos were still viable and then were transferred to recipients for subsequent development. When 339 embryos were stored for 0, 1, 2, 3, 4, 5, 6, and 7 days and then transferred; 33, 30, 7, 19, 4, 0, 0, and 0, respectively, developed into live fetuses. These low percentages of mouse embryos developing to term were expected due to the very close synchrony between the donor and recipient required in this species. Preliminary results have shown that cow embryos may be stored under similar conditions, with similar percentages of embryos developing in culture, but higher percentages developing following transfer.

These results show that although embryos cannot be stored in a refrigerator at $4^{o}C$ until more recipients are cycled (approximately 10 days), they may be stored under these conditions for several days until other recipients which are a few days behind the donors in their estrous cycle can be obtained.

Re-Examination of Fertilization In Vitro

Bradley A. Didion and Charles N. Graves

The ovulated egg of farm animal species is surrounded by a tough outer coating called the zona pellucida and outside the zona one or more layers of cumulus cells. In these species the process of fertilization begins with the sperm cell digesting its way between the cumulus cells and penetrating the zona pellucida (Fig. 1). Once the sperm cell has penetrated through the zona, it then must make contact with the outer membrane of the egg, vitelline membrane, (Fig. 1) in order for fertilization to continue. The egg is then activated, as a result of sperm incorporation, which results in changes occurring within the egg, allowing the formation of the male and female pronuclei. The male and female pronuclei subsequently fuse and the egg starts its many divisions to eventually form a new animal.

Before the sperm cell can cross through the zona pellucida it must undergo a maturation phase termed "capacitation". At the end of capacitation, the sperm cell loses its acrosome cap which is termed the "acrosome reaction" (Fig. 2). Only acrosome reacted sperm are able to fuse with the egg vitellus and fertilize the egg.

Fertilization in a culture dish, or *in vitro* fertilization, is now possible in cattle. To date, seven calves have been born when eggs fertilized *in vitro* were transferred to recipient females. However, more research needs to be conducted in this area to achieve greater fertilization rates. At present, fertilization success varies to 0 percent to 80 percent. One limiting factor for obtaining high fertilization rates *in vitro* is capacitation of the sperm.

Our objective has been to re-examine the significance of capacitation and its requirement for fertilization. In this study we have chosen the mouse because 1) the fertilization process is similar in the mouse to that of farm animal species; 2) it is easy to gather a large number of unfertilized eggs using superovulation; 3) the egg cytoplasm is very clear, relative to farm species eggs, which makes detecting fertilization very easy; and 4) the cost per mouse is low.

We have shown that when the zona pellucida is removed enzymatically, uncapacitated sperm will attach and bind to the egg vitellus. However, the uncapacitated sperm can not penetrate the egg because it has not undergone capacitation and the acrosome reaction. In these experiments we took zona pellucida-free eggs and let uncapacitated

sperm bind to the egg (Fig. 3). The next step was to artificially fuse these uncapacitated sperm to the egg by using polyethylene glycol (PEG) which has been shown to have fusogenic properties. The treated eggs were then incubated for 6-8 hours and examined for fertilization. Since it was imperative that the sperm not undergo capacitation and acrosome react within the incubation period, we chose to use rabbit sperm which need approximately 10 hours to undergo capacitation (mouse sperm have a 1-2 hour capacitation time which could confound the results).
When the eggs were checked for evidence of fertilization, 50 percent of the eggs had sperm which had fused to the vitelline membrane with part of the genetic material of the sperm being released into the egg. However, these fused sperm were not totally incorporated into the egg as has been shown to occur during normal fertilization. Control eggs, prepared in the same manner but without exposure to PEG, had no sperm fused to the vitellus.

In the PEG-treated eggs, it was observed that although the PEG induced fusion of the sperm to the egg, the egg remained unactivated. This lack of activation of the egg which occurred with the PEG-fused sperm is in contrast to the activation of the egg and subsequent formation of the female pronucleus which occurs following sperm fusion during the normal fertilization process. If we artificially activated the egg with alcohol, then fused the uncapacitated sperm to the activated egg, the sperm was incorporated with subsequent male and female pronuclei development.

When we fused mouse thymocytes (cells from the thymus gland) to eggs, there was a transfer of genetic material from the thymocyte to the egg (as many of 6 thymocyte chromosome sets have been found in one egg). However, there was no egg activation. If we activated the egg and then fused the thymocyte to the activated egg, the thymocyte nuclei formed thymocyte pronuclei.

The results suggest that uncapacitated sperm artificially fused to an egg contribute genetic material to the egg, but fail to activate that egg. The results also suggest that activation of the egg may be dependent upon factors other than fusion of sperm and egg. At present we are using electron micrographic analysis to determine the association of the sperm with the vitelline membrane.

These studies on sperm attachment and fusion are increasing our knowledge of the critical factors involved in the fertilization process. They will help us to explain why sperm of some males have low fertilization rates.

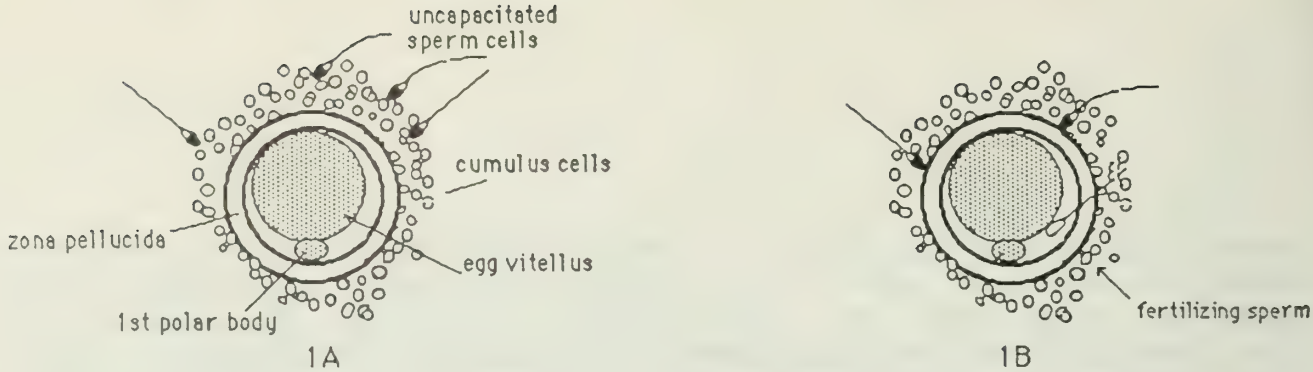


Figure 1. A) Uncapacitated sperm approaching ovulated egg; B) capacitated sperm has penetrated through the zona pellucida and now fused with the egg vitellus allowing fertilization to occur. Other sperm are trying to penetrate through the zona.

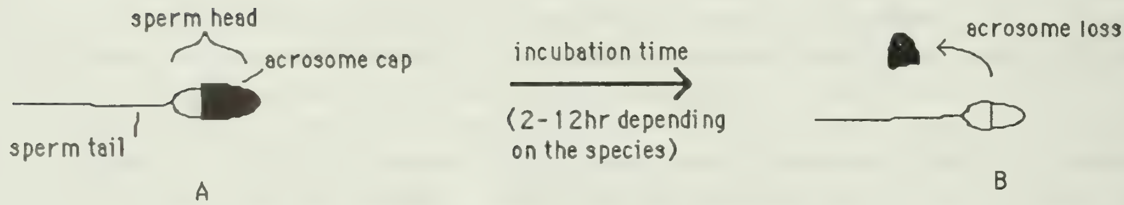


Figure 2. A) Uncapacitated sperm unable to fertilize; B) Capacitated sperm now acroxome reacted and able to penetrate through the zona pellucida and fertilize the egg.

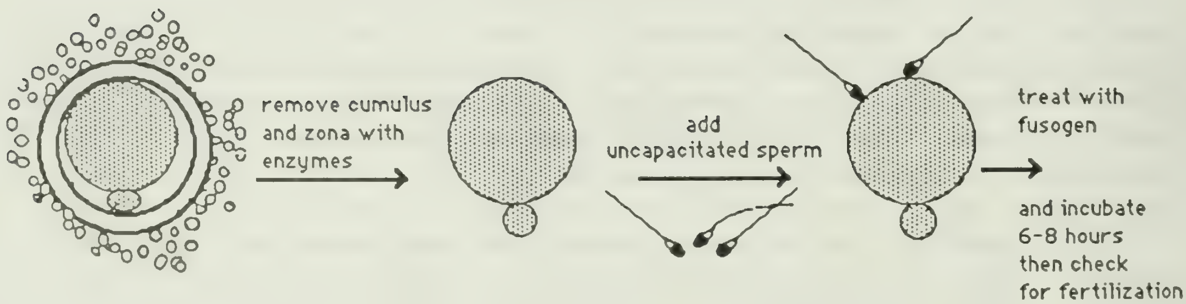


Figure 3. Artificially fusing uncapacitated sperm to zona free eggs.